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RAPPORTS

ET

PROCÈS-VERBAUX DES RÉUNIONS

Volume 140

Part II

CONTRIBUTIONS TO SPECIAL SCIENTIFIC MEETINGS 1954

En Commission chez

ANDR. FRED. HØST & FILS

COPENHAGUE

Prix: Kr. 15.00

Décembre 1955

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HERRING TAGGING TECHNIQUES AND RESULTS

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Introduction.

During the 1954 Annual Meeting of the Council in Paris, a special meeting on Herring Tagging was held. The Chairman was Dr. W. C. Hodgson and the Recorder, Mr. Olav Aasen. Contributions were made by the following:—

Mr. C. Gilis, Belgium.
Mr. J. C. Stevenson, Canada.
Dr. E. Bertelsen, Denmark.
Dr. A. J. C. Jensen, Denmark.
Mr. G. C. Bolster, England.
M. J. Ancellin, France.
Dr. Árni Friðriksson, Iceland.
Dr. H. Wood, Messrs. Parrish and McPherson, Scotland.
Dr. H. Höglund, Sweden.

It is regretted that, for reasons of economy, the most interesting and comprehensive report submitted by Mr. Stevenson could not be reproduced here in full, so the author has been good enough to prepare a summary of his paper.

In the comparatively short time which has elapsed since herring tagging began in European waters, the results have been quite remarkable in many respects. Migrations which had been suspected from a study of the scales and other characters have been confirmed by tagging and new routes have been discovered, and while these findings are both important and interesting, they are also an encouragement to further efforts, for there is still much to be done.

We are advancing the knowledge of the herring fisheries to such an extent that, so far as the North Sea is concerned, we can no longer talk parochially about our East Anglian herrings, our Dogger Bank herrings or our Sandettié herrings, because all these are connected at some time or other with fish from the northeast of Scotland, the Fladen Ground and the Skagerak. And the changes which have taken place in the East Anglian fishery since 1951 have also shown that we must broaden our outlook and concentrate on the interdependence between the different North Sea herring groups, and the best tool for this purpose is the tag.

Finally our thanks are due to all those who have devised tagging methods and also to those who have so laboriously carried them out.

W. C. Hodgson

1.

Note sur le Marquage des Poissons au moyen de l'Aiguille Chirurgicale de Reverdin.

Par J. Ancellin

Au cours de la campagne océanographique du "Président Théodore Tissier" à Terre-Neuve en 1952 et au cours de sorties à bord des chalutiers sur les lieux de pêche du hareng "guai" dans le sud de la Mer du Nord, nous avons eu l'occasion de mettre au point une technique de marquage dont nous donnerons ici une brève description.

Ce nouveau système de marquage comporte l'utilisation de l'aiguille chirurgicale de Reverdin, employée en médecine humaine et vétérinaire pour la suture des tissus incisés.

Cette aiguille, plus ou moins recourbée, suivant les modèles, est pourvue d'une poignée, et d'un chas qui s'ouvre et se ferme à volonté au moyen d'une tige actionnée par glissement.

Pour le marquage du poisson la méthode consiste, en un *premier temps*, à traverser au moyen de l'aiguille la partie musculaire (dos du poisson) servant de support à la marque, puis à insérer l'attache en fil nylon dans le chas ouvert de l'aiguille.

Dans un *deuxième temps* le chas est refermé, et, en retirant l'aiguille, l'attache en nylon est passée à travers la masse musculaire. Elle est ensuite libérée dans un *troisième temps* et sa boucle fixée à la marque elle-même.

Parmi les différents types de marques pouvant être utilisés, nous retiendrons les trois suivants:—

1° — Marque constituée par une plaquette en celluloïde fort (1/2 mm.) sur laquelle sont gravés à chaud l'indicatif et le numéro. Deux encoches latérales pratiquées à l'une des extrémités de la plaquette et aboutissant chacune à un trou percé au moyen d'un poinçon sont destinées à recevoir la boucle de fixation.

2° — Marque en métal mou refermée à l'aide d'une pince sur les deux anses formées par les boucles libres.

3° — Marque hydrostatique type Lea: la marque est passée dans la boucle libre puis, pour assurer sa fixation, repassée sous un des chefs de cette même boucle.

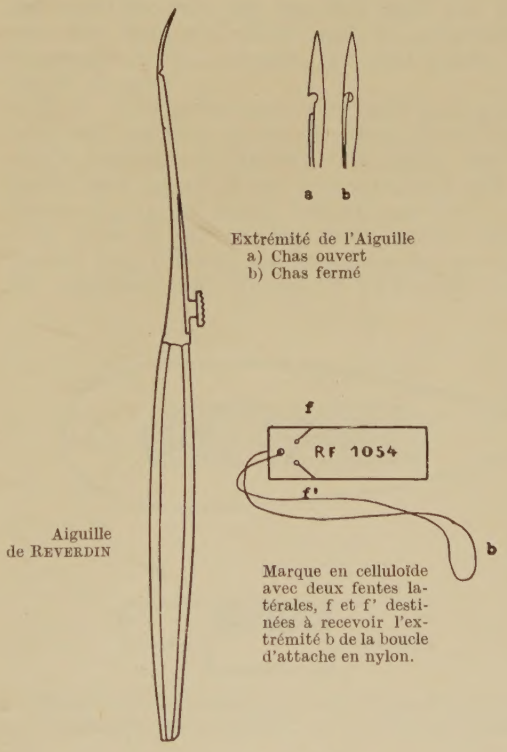
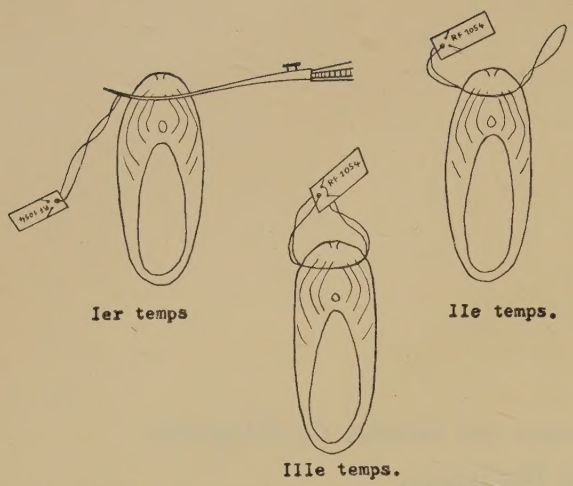

a b
Extrémité de l'Aiguille
a) Chas ouvert
b) Chas fermé
f
RF 1054
f'
b
Aiguille de Reverdin
Marque en celluloïde avec deux fentes latérales, f et f' destinées à recevoir l'extrémité b de la boucle d'attache en nylon.

Figure 1.



(La boucle d'attache est passée dans les fentes latérales de la marque)

Figure 2. Marquage des poissons à l'aide de l'aiguille de REVERDIN.

Au cours des différents essais qui ont été effectués, nous avons pu nous rendre compte que cette méthode a l'avantage de ne nécessiter qu'un petit nombre de manipulations, d'être rapide et de pouvoir se pratiquer même lorsque les conditions de travail sont défavorables.

Elle assure d'autre part une bonne fixation de la marque, ce qui n'est pas toujours le cas avec les agrafes métalliques par exemple.

Par ailleurs, à condition que l'aiguille soit de grosseur convenable, elle n'entraîne qu'une blessure relativement minime; en particulier lorsque des écailles assez épaisses doivent être traversées elle évite de provoquer des déchirures par glissement.

Enfin, cette méthode de marquage peut s'appliquer à n'importe quelle espèce de poisson. Elle convient particulièrement pour les poissons de moyenne et grande taille, tels que la morue, l'églefin, le colin noir, le hareng . . . Mais elle pourrait également être utilisée avec profit, à condition d'employer des aiguilles de REVERDIN de petit calibre, pour le marquage de poissons beaucoup plus petits, tels que la sardine.

Jusqu'à présent toutefois elle n'a été appliquée qu'à titre d'essai. Elle a comporté, entre autres, des marquages de morue, aux Iles Saint-Pierre et Miquelon: sur les 250 individus marqués[1]) en Septembre 1952, 5 ont été recapturés; une de ces morues a été retrouvée au bout de 10 mois, le long de la côte sud de Terre-Neuve, à 40 milles de Saint-Pierre et Miquelon.

[1]) Plaquettes en celluloïde.

2.

Danish Herring Tagging in the North Sea, 1949-1951.

By E. Bertelsen

Herring tagging has been carried out on the Fladen Ground in August or September in each of the years 1949 to 1951. As the experiments were made during cruises which were mainly concerned with experimental fishing they were of a preliminary character only. A total of 1993 herrings were tagged (280 in 1949, 766 in 1950 and 947 in 1951) and 34 tags or 1.7 % were returned. Although the experiments showed that fairly satisfactory results could be obtained by the methods used, lack of personnel and recent alterations in the Danish herring fishery made it necessary to postpone further experiments in this area.

Technique.

In 1949 the tagging was made from a chartered Danish fishing cutter; in 1950 and 1951 from the experimental cutter "Jens Væver". The herrings were fished in short hauls with a herring trawl at depths of 60 to 80 fathoms. The catch was kept in a tank with running water and only herrings which had kept most of their scales were tagged.

In 1949 and 1951 those with the swimbladder inflated to such a degree that they were unable to dive, were rejected also. Due to the great fishing depth these fish made up a large percentage of the catch and especially of those otherwise uninjured. In 1950 herrings in this condition were tagged and liberated 10 to 20 m. below the surface by means of a special tub with a lid which could be opened by a messenger device. Of 349 herrings liberated this way 7 were returned. At the same time 431 herrings which were able to swim normally in the tank were tagged and liberated at the surface. 14 of these were observed to float and were eaten by gulls; 5 tags were returned. Although the returns are very few, they indicate that the method can be used.

The tag used in 1949 was the "Danish flag" designed by Dr. Tåning.[1]) This is a rectangular label of flexible red plastic attached in front of the dorsal fin by a silver wire. The wire was inserted by help of a hollow needle. 280 fish were tagged and 14 tags or 5 % were returned.

In 1950 two new types of tags were introduced. One is a pear-shaped plate of Alcathene[2]), i. e., a plastic which is slightly lighter than water. The other is of the same material and shape but has a rectangular groove on one side. In this groove it carries imbedded in wax an iron tag of nearly the same size and shape as those used for internal tagging (Figure 1). In the fish meal factories the wax will melt and the iron tag, free from the plastic and its attachment, can be caught by the magnets. The total density of this tag is above 1.

Each of the three types were tried both with silver wire and different types of nylon thread (spun or single thread) attachments. The nylon thread was bound in a loop and was drawn through the fish by means of a special needle with an open eye.

A total of 766 herrings were tagged (168 with Danish flag, 152 with the Alcathene tag and 446 with the combined tag). 12 tags or 1.6 % were returned.

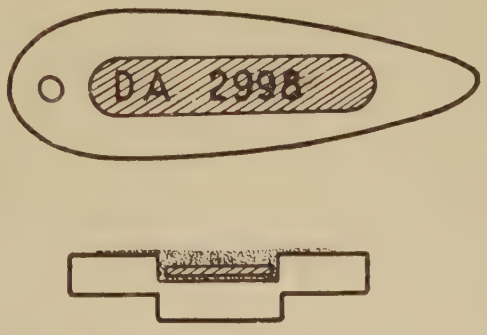


Figure 1. Combined tag. In the section iron is shown hatched, wax spotted, and Alcathene white.

[1]) Å. V. Tåning: "Marking of Herring in the North Sea." Ann. Biol., **6**, 1949, p. 170 and "A Guide to Fish Marks." Journ. du Cons., **19**, 2, 1953, p. 254.

[2]) (cf. "A Guide to Fish Marks," loc. cit., p. 253).

In the 1951 experiment the same three tags were used. They were all attached with a black, braided, soft nylon line.

947 herrings were tagged (341 with Danish flag, 238 with the Alcathene tag and 368 with the combined tag). Only 8 tags or 0.8 % were returned.

Due to the low number of returns a comparison of the different tags and methods of attachment gives rather uncertain results.

The use of silver wire and nylon thread for attachment can be compared only in the 1950 experiment. No significant difference was found:—

	No. tagged	No. of returns	%
Silver.....	361	6	1·7
Nylon	405	6	1·5

In the comparison between the three types of tags the experiment of 1950 and 1951 can be taken together:—

	No. tagged	No. of returns	%
Alcathene tag (without iron).	390	9	2·3
Danish flag	509	5	1·0
Combined tag (Alcathene with iron)	814	6	0·7

In this table the tags are arranged according to their density. The Alcathene tags which in contrast to the others are slightly lighter than water have given a result which is somewhat better than the others.

Only 4 of the returned herrings from the 3 experiments had been more than two months at sea after the tagging. Among these both materials for attachment and all three types of tags were represented: 1 Danish flag with silver wire (211 days), 1 Danish flag with nylon (103 days), 1 Alcathene with nylon (120 days) and 1 combined tag with silver wire (ca. 80 days).

The low percentage of returns, 1.7 % from all the experiments and types of tags taken together, must be mainly due to the difficulty in getting sufficiently undamaged fish from the relatively great depth on Fladen Ground where they can be caught by means of trawl only, and not to the tagging technique itself. Dr. Höglund (p. 20) reports that of 1115 trawl-caught herring tagged by him in the same area, season, and years but with the Lea hydrostatic tag, only 10 tags or 0.9 % were returned.

From Dr. Jensen's report on the Danish herring tagging inside the Skaw (p. 30) it appears that under conditions where herrings can be taken by pound-nets the Alcathene tag may give far better results.

Unfortunately an attempt to make comparative tagging with Dr. Höglund in the Bohuslän archipelago in March 1950 partly failed (cf. Dr. Höglund's report p. 20). During my short visit only 53 herrings were tagged with either the Danish flag or the Alcathene tag. 7 tags or 13 % were returned. In the total Swedish experiment (February-March 1950) 1016 herring were tagged with the Lea hydrostatic tag. 155 tags or 15 % were returned.

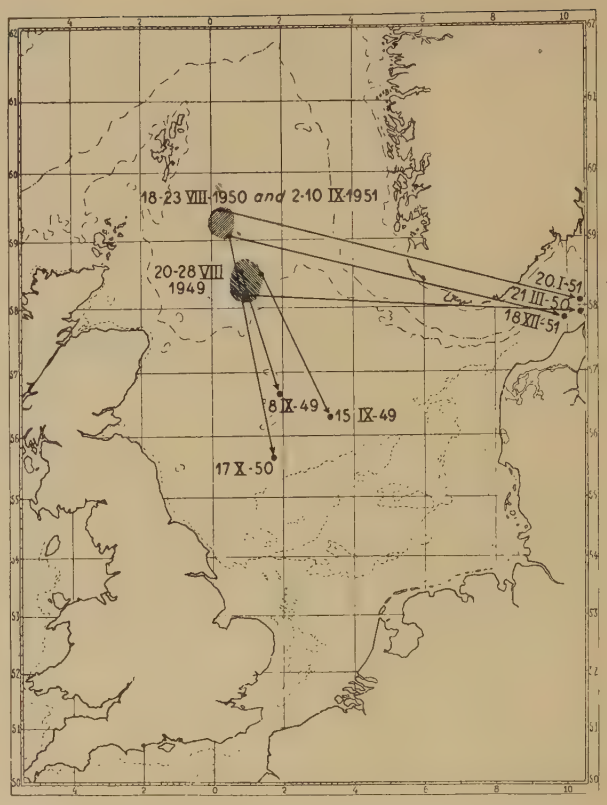


Figure 2. Areas where tagging was carried out and positions and dates of recaptures outside the Fladen Ground area.

Observed Migrations.

Most of the returned tags came from the Fladen Ground shortly after tagging. The position of tagging and recapture of the 6 herrings which had migrated longer distances are mapped in Figure 2.

Three were caught in the central North Sea north of Dogger Bank in September-October during the year of tagging, and besides these, one spent herring was returned in November from an unknown position in the North Sea.

The remaining 3 were caught in the Skagerak near the Skaw in the winter following the tagging (18/12, 20/1 and 21/3).

The observations thus confirm the theory that Fladen Ground herrings move towards the Dogger Bank in the autumn for spawning and spend the winter in Skagerak and Kattegat.

3.

English Tagging Experiments.

By G. C. Bolster

In 1951 experiments were carried out from Lowestoft with two types of herring tag. These were the Lea hydrostatic and the Lowestoft metal tag. The latter was made of aluminium alloy and measured $1'' \times {}^{1}/_{4}'' \times {}^{1}/_{16}''$. It was painted red, carried a serial number and was attached to the fish by a wire bridle similar to that used with the Lea.

The Hodgson tag which was evolved from the metal tag, is made of flat transparent plastic material, embedded in which instructions to the finder and a serial number are printed on yellow base. The tag measures 37.5×10 mm. and is 0.6 mm. thick. During 1952 this tag was fitted to the fish by a wire bridle placed in front of the dorsal fin in the same manner as the Lea hydrostatic tag. The recaptures during the year were 0.76 % for the Lea; 0.29 % for the Hodgson and, for the Scottish one-man tag, (fitted in front of the dorsal fin but with a wire and nylon toggle) 0.57 %.

In 1953 it was decided to adapt a toggle fitment similar to that used with the Scottish one-man tag for the Hodgson tag. This, it was considered, would allow of a quick method of tagging with the Hodgson tag, and one which would give a higher percentage return. (In 1952 Scottish one-man with wire and nylon toggles 0.57 %: Hodgson with wire bridles 0.29 %).

As well as altering the fitment of the Hodgson, the position in which the tag was attached to the fish was changed from in front of the dorsal fin to just behind it. The advantage of this innovation is thought to be twofold:—

(1) In this position the tag is less likely to interfere with the stabilizing function of the dorsal fin.

(2) When fish are recaptured in gill nets, there is less likelihood of the tag, because of its more distal position, being torn out or snagged by the nets. The percentage return of this tag thus fitted increased in 1953 to 0.45 %.

During 1951 and 1952, all tagging was carried out from the research vessels "Onaway" and "Platessa".

Table 1.

Tagging by Commercial Vessels.

1953

Date	Vessel	Number of fish tagged	Area
7. IX	"Honeydew"	47	Whitby
8. -	"BF 307"	103	—
11. -	—	17	—
14. -	—	43	—
17. -	—	84	—
18. -	"Margaret Read"	36	—
20. X	"Vesper Star"	60	E. Anglia
5. XI	—	8	—
26. X	"Lilacina"	6	—
17. XI	—	89	—
18. -	—	146	—
28. X	"Kindred Star"	11	—
30. -	—	17	—
3. XII	"Betty Leslie"	200	Channel
4. -	—	299	—
8. -	"Friendly Star"	136	—
10. -	—	198	—
	Total...	1500	

Beginning in September 1953 tagging was operated from commercial drifters. At first fish were taken from the nets and placed in a rubber tank containing sea water from which they were subsequently tagged and released. Later, working on commercial vessels, and using the Hodgson tag with wire and nylon toggles, it was found that less time was required if the fish were tagged as they came out of the net than if they were placed in a collecting tank first. This method obviated the necessity of handling the fish twice. Furthermore, in rough weather tagging from a tank is not practicable. By this method, 0.8 % returns have resulted to date with the Hodgson tag from one experiment using 1000 fish in North Shields during May 1954.

Experiments comprising comparison of Lea and Hodgson tags attached by the same type of toggle are being undertaken in 1954.

Table 2. **Herring Taggings 1951, 1952, and 1953.**

1951

Date	Vessel	Number of fish tagged	Area
12. XII	"Onaway"	81	Channel
14. -	—	3	—
17. -	—	34	—
	Total...	118	

1952

25. VIII ...	"Platessa"	295	Whitby
26. - ...	—	434	—
29. - ...	—	395	—
3. IX	—	221	—
	Total...	1345	
16. X	—	362	E. Anglia
2. XI	—	510	—
12. -	—	10	—
13. -	—	339	—
15. -	—	7	—
16. -	—	38	—
	Total...	1266	
23. I.....	"Onaway"	101	Channel
16. II.....	—	7	—
13. XII	—	95	—
14. -	—	71	—
	Total...	274	
14. XI	—	36	E. Anglia
	Grand total:	2921	

1953

14. I.....	"Onaway"	9	Channel
19. -	—	77	—
22. -	—	9	—
23. -	—	19	—
20. II.....	—	3	—
15. XII	—	70	—
	Total...	187	

1953

Date	Vessel	Number of fish tagged	Area
14. VIII ...	"Onaway"	9	Whitby
18. - ...	—	231	—
19. - ...	—	105	—
21. - ...	—	62	—
	Total...	407	
6. XI	—	20	E. Anglia
10. -	—	80	—
19. -	—	110	—
20. -	—	50	—
30. -	—	64	—
1. XII	—	24	—
4. -	—	7	—
11. -	—	114	—
	Total...	469	
15. II.....	"Platessa"	72	E. Anglia
5. X.....	—	255	—
7. -	—	20	—
8. -	—	28	—
3. XI	—	45	—
5. -	—	53	—
6. -	—	67	—
10. -	—	170	—
13. -	—	89	—
	Total...	799	
19. II.....	—	14	W. deep water
	Grand total:	1876	

Table 3.
Summary of Tables 1 and 2.

	1951	1952	1953		Total
	Research Vessels	Research Vessels	Research Vessels	Comm. Vessels	
Whitby ..	—	1345	407	330	2082
E. Anglia .	—	1302	1282	337	2921
Channel ..	118	274	187	833	1412
Total	118	2921	1876	1500	6415

Table 4.
Type of Tags used.

1951	Metal	Lea	Hodgson	Scot. one-man	Total
Channel...	99	19	—	—	118
1952					
Whitby ...	—	433	432	480	1345
E. Anglia ..	—	78	264	960	1302
Channel...	—	148	—	126	274
1953					
Whitby ...	—	20	717	—	737
E. Anglia ..	—	454	1164	1	1619
Channel...	—	3	908	109	1020
	99	1155	3485	1676	6415

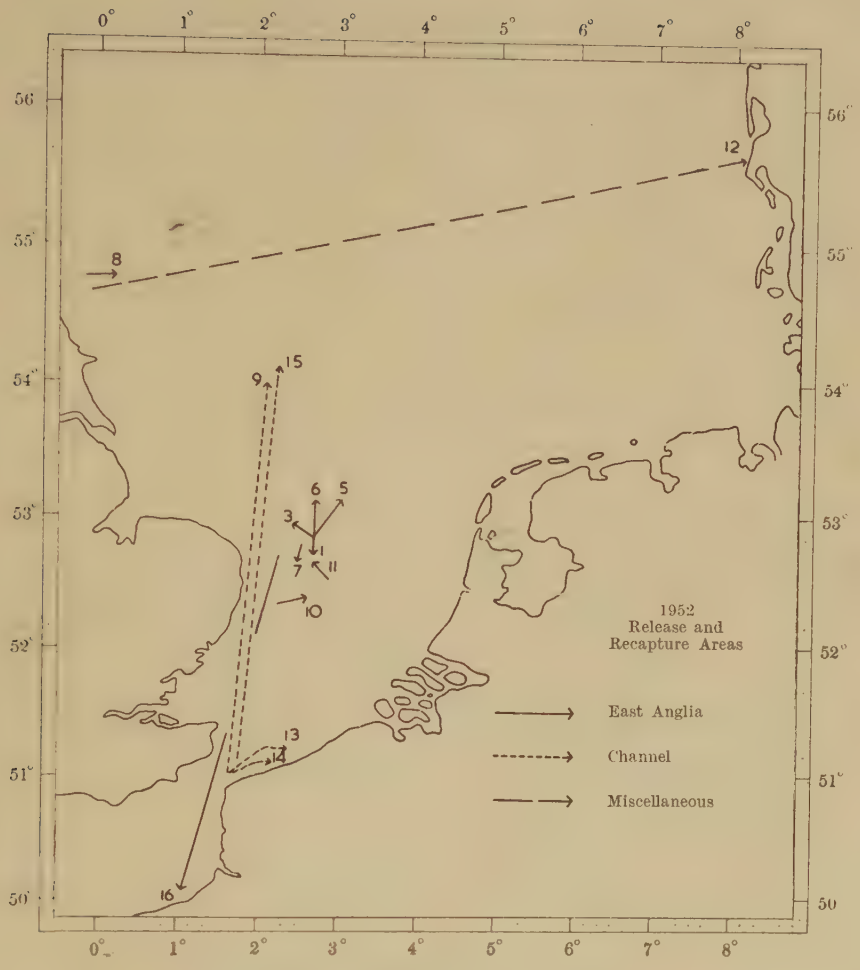


Chart 1. Herring migrations, 1952 (see Table 5).

Table 5. **Herring Migration, 1952.**

No.	Released			Recaptured			Days free	Dist. trav. n. miles	Remarks
	Date	Lat.	Long.	Date	Lat.	Long.			
1	2.11.52	52°49′N.	2°38·5′E.	3/4.11.52	52°46·5′N.	2°38′E.	1	3	—
2	2.11.52	52°49′N.	2°38·5′E.	3/4.11.52	Smith's Knoll Area		1	?	Too few to plot
3	2.11.52	52°49′N.	2°38·5′E.	4.11.52	52°53′N.	2°31′E.	2	5½	—
4	2.11.52	52°49′N.	2°38·5′E	3/4.11.52	Smith's Knoll Area		1—2	?	Too few to plot
5	16.10.52	52°49′N.	2°36′E.	18/19.10.52	53°06′N.	2°53′E.	2	20	—
6	2.11.52	52°49′N.	2°38·5′E.	6.11.52	53°0′N.	2°38′E.	4	11½	—
7	16.11.52	52°48′N.	2°30′E.	17/18.11.52	52°44·5′N.	2°30′E.	1	3	—
8	29. 8.52	54°35′N.	0°15·5′W.	29/30. 8.52	54°35′N.	0°10′W.	1	3	—
9	16. 2.52	50°53′N.	1°30′E.	10. 9.52	? Silver Pits		208	200 approx.	German trawler
0	12.11.52	52°23′N.	2°15′E.	15.11.52	52°24′N.	2°26′E.	3	6	—
1	16.11.52	52°35′N.	2°43′E.	? 17.11.52	52°46′N.	2°33′E.	? 1	12	—
2	4. 9.52	54°31′N.	0°10′W	23.12.52	55°42′N.	8° 8′E.	110	? 310	Tag found on beach
3	14.12.52	50°48′N.	1°30′E.	10/20. 1.53	"Flemish Coast"		27—37	45—80	—
4	23. 1.52	50°50′N.	1°32′E.	? 28. 1.53	Near Calais		? 5	? 20	—
5	17.12.51	50°55′N.	1°40′E.	15. 3.52	54°5′N.	2°20′E.	89	200	—
6	2/16.11.52	52°43′N.	2°18′E. approx.	24.11.52	49°46′N.	1°5′E.	8—22	170 approx.	—
7	2.11.52	52°49′N.	2°38·5′E.	? 11.52	Smith's Knoll Area		?	?	Too few to plot

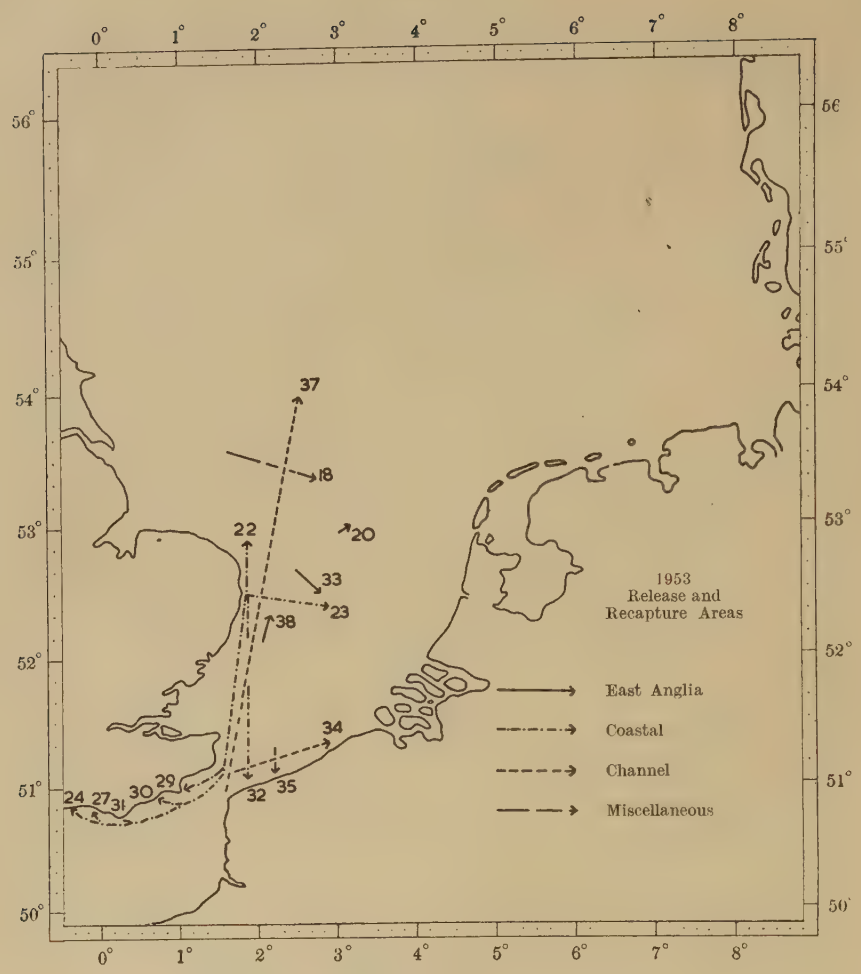


Chart 2. Herring migrations, 1953 (see Table 6).

Table 6. **Herring Migration, 1953.**

No.	Released			Recaptured			Days free	Dist. trav. n. miles	Remarks
	Date	Lat.	Long.	Date	Lat.	Long.			
18	5.10.53	53°40′N.	1°31′E.	7.10.53	53°34′N.	2°20′E.	2	29	—
19	20.10.53	52°34′N.	2°11′E.	21.10.53	?	?	1	?	Too few to plot
20	30.10.53	52°54′N.	2°48′E.	30.11.53	52°56′N.	2°54′E.	1	4	—
21	10.11.53	52°43′N.	2°10′E.	13.11.53	?	?	3	?	Too few to plot
22	19.11.53	52°22′N.	1°47′E.	22.11.53	52°43′N.	1°43·5′E.	2½	21	—
23	19.11.53	52°22′N.	1°47′E.	26.11.53	52°12·5′N.	2°42′E.	7	35	—
24	20.11.53	52°26′N.	1°46′E.	4.12.53	50°47′N.	0°45′W.	14	170	—
25	4.12.53	50°45′N.	1°33′E.	5.12.53	?	?	1	?	Too few to plot
26	3.12.53	50°45′N.	1°33′E.	3/5.12.53	?	?	1—2	?	Too few to plot
27	19.11.53	52°22′N.	1°47′E.	1.12.53	50°48′N.	0°25′W.	12	160	—
28	4.12.53	50°45′N.	1°33′E.	7.12.53	?	?	3	?	Too few to plot
29	30.11.53	52°23′N.	1°47′E.	7.12.53	50°54′N.	0°58′E.	7	112	
30	19.11.53	52°24′N.	1°47′E.	17.12.53	50°55′N.	0°45′E.	28	126	
31	30.11.53	52°23′N.	1°47′E.	6.12.53	50°46′N.	0°20′E.	6	140	
32	20.11.53	52°21′N.	1°47′E.	?.12.53	English Channel		10—20	? 80	
33	5.11.53	52°28′N.	2°18′E.	7.11.53	52°20′N.	2°36′E.	2	13	—
34	11. 1.54	51° 2′N.	1°35′E.	11. 2.54	? Ostende		31	? 50	—
35	18.11.53	51° 6′N.	2° 0′E.	23.11.53	51° 4′N.	2° 0′E.	5	3	—
36	18.11.53	51° 6′N.	2° 0′E.	27.11.53	?	?	?	?	Too few to plot
37	3.12.53	50°45′N.	1°33′E.	? 3.54	54° 5′N.	2°10′E.	86—117	200	—
38	30.11.53	52°22′N.	1°46′E.	12. 5.54	52°23′N.	1°46′E.	163	?	—

4.

Marquage de Harengs en Belgique.

Par Ch. Gilis

Marquages effectués en Collaboration avec la France.

C'est en Janvier 1951 que les premiers essais de marquage de harengs (guais) ont été entrepris sur les côtes franco-belges. Ceci à l'initiative du Dr. Ancellin, Directeur du Laboratoire de l'Institut Scientifique et Technique des Pêches Maritimes à Boulogne-sur-Mer, mais en collaboration avec la Belgique qui a prêté le bateau de recherches "Hinders" ainsi que le personnel technique de l'Institut d'Etudes Maritimes d'Ostende.

En Janvier 1952, le Dr. Ancellin, ayant repris ces expériences sur les côtes franco-belges, la Belgique lui a encore prêté son concours en hommes et en matériel.

Comme ces marquages ont été faits à l'initiative de la France, nous supposons que le Dr. Ancellin communiquera les détails sur les méthodes employées et les résultats obtenus.

Marquages effectués par l'Institut d'Etudes Maritimes d'Ostende.

La Belgique a effectué les premiers essais de marquage pendant l'hiver 1952—53. Comme le temps était peu propice pour ce genre d'opérations, au cours des sorties, on est parvenu à marquer 176 harengs seulement dans les conditions requises.

Jusqu'ici aucune récapture nous a été signalée, ce qui n'est pas étonnant étant donné le petit nombre d'individus marqués.

Ces marquages ont été effectués au moyen de la marque de "Lea".

Le programme de travail de 1954 de l'Institut d'Etudes Maritimes prévoit la reprise des marquages de harengs au cours du mois de Décembre.

5.

Tagging of Herring in Icelandic Waters.

By Á. Friðriksson

1. Introduction.

The Icelandic herring taggings constitute a part of the big Norwegian-Icelandic herring tagging scheme, which was definitely planned in 1947. It was the intention to start taggings off the north coast of Iceland in the summer of that year, but owing to various unfavourable circumstances, amongst other things the lack of herring, the plan had to be postponed until the next year. After making the necessary preparations the taggings were started in Norway in the spring of 1948, conducted by Mr. Olav Aasen and myself. Since then regular taggings have been continued in both countries.

Table 1. Number of tagged Herrings, liberated at Iceland.

Year	N. and E. Coast	S. and SW. Coast		Total
	Int. Tags	Int. Tags	Ext. Tags	
1948.....	7,475	—	—	7,475
1949.....	—	—	—	—
1950.....	1,321	—	—	1,321
1951.....	3,064	—	—	3,064
1952.....	17,308	—	—	17,308
1953.....	10,181	4,192	898	15,271
1954.....	8,783	4,571	408	13,762
Total.....	48,132	8,763	1,306	58,201

2. Number of Herrings liberated.

In Table 1 a survey is given of the number of herrings which have been liberated in Icelandic waters until now, altogether 58,201. In Icelandic waters the taggings have to take place in the open sea, sometimes far offshore and often in rough weather, and a special boat has to be chartered for the purpose. The table shows that the work has been continued annually except in 1949, when no funds could be raised to carry out the plan. In some years it has been very hard to get herring for the taggings, as will be seen clearly from the table. In the first column we see the year of tagging, in the following three columns the number of herring tagged, and finally in the last column the totals are shown. The major part of the taggings have been made off the north coast, but in 1953 taggings were inaugurated in the south too. 56,895 herrings have been tagged internally, and 1306 externally, but no double taggings have been made.

3. Number of Returns.

We will now consider the results of the taggings and confine ourselves to deal with the north-coast herring only. It can just be mentioned that we have had local returns of the herrings which were tagged in the south, but have got *no* tags from southern herring in the north, and *no* tags of northern herring in the south, so far.

The most important result of the Icelandic herring taggings in the north is unquestionably that they have revealed a large-scale migration of these fish between the spawning grounds in Norway and the waters of northern Iceland. Altogether we have got 1495 returns of north-coast herring, 379 in Icelandic and 1116 in Norwegian waters. The relative number of returns from each experiment ranges from 1.9 to 4.7 %.

As will be seen from Figure 1 each experiment has given returns every year—with two exceptions, 1948 (no returns at Iceland in 1952) and 1951 (no returns at Iceland in 1954), both in Norway and Iceland, and the migration to Norway has been enormous.

4. The Size of the Herring, migrating from Iceland to Norway.

It is of importance to know if all herring, which in a given summer are found off the north coast of Iceland, migrate to Norway, or if there is any selection, for instance, according to size. In Figure 2 we see the size distribution of all herring measured in North Iceland in the summer of 1953, and of the

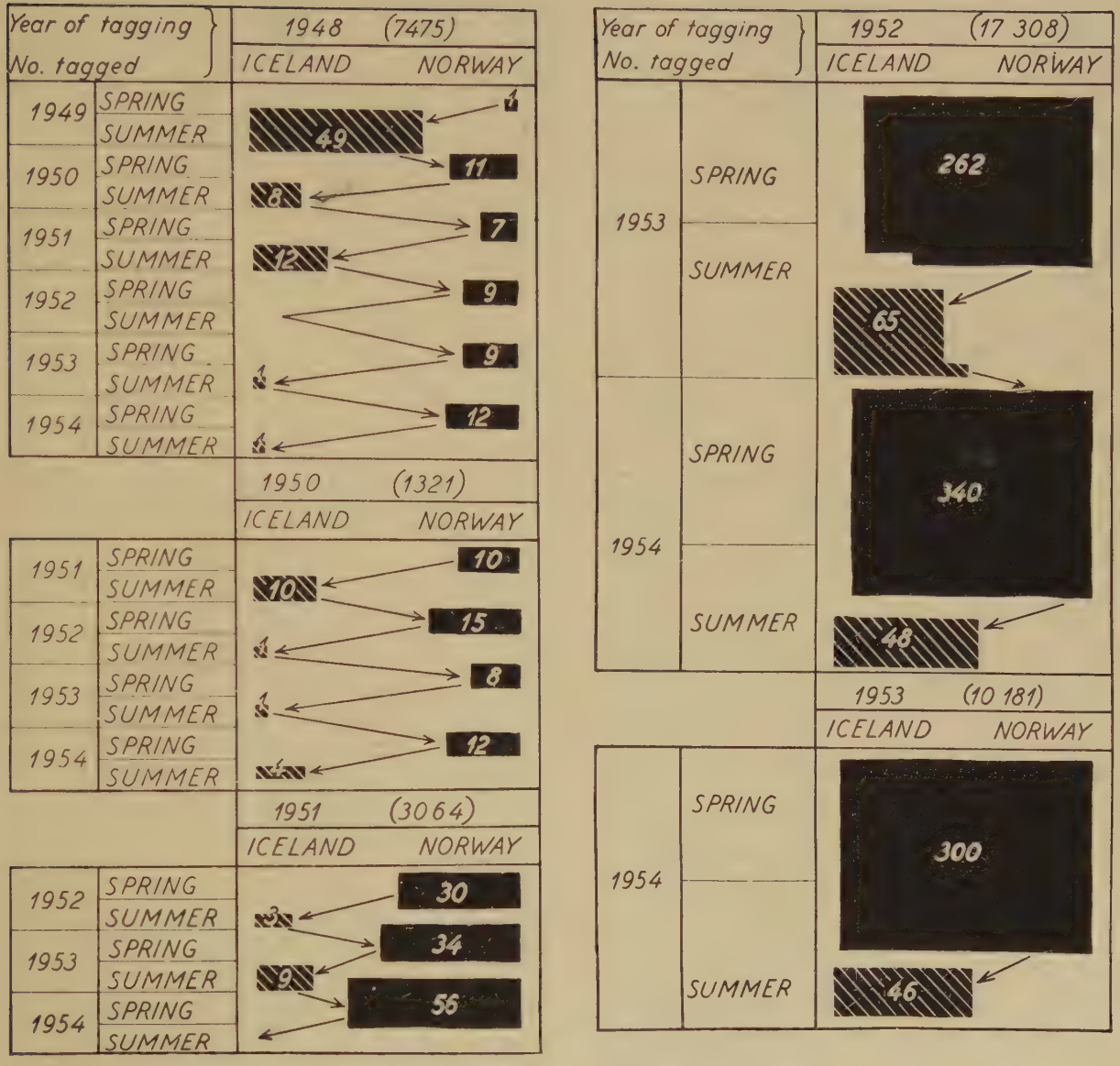


Figure 1. Total number of returns in Iceland and Norway.

herring, which were tagged and measured there in the same year. In Figure 3 the size of the herring tagged in 1953 is compared with that of the herring from this experiment which were recaptured in Norway 1954. The tops of both curves have been brought to cover each other in order to simplify the comparison. The material is not large enough to justify any general conclusion but there seems to be the tendency that the middle-sized herring, which I have earlier called the main stock, migrates, *in extenso*, whereas the largest herring, the residual ones, and the smallest ones, probably young fish of Icelandic origin, show a lesser trend to transatlantic migrations.

5. Selection of migrating Herring as to Time and Place of Recapture.

The interval of time from the first to the last taggings off North Iceland in a season, usually amounts to a month or more. It could therefore be expected that herring, which are tagged on the first day of the season should appear somewhat earlier on the Norwegian spawning grounds than those which were tagged on the last day, and perhaps, they should appear more southerly or farther north than the other ones. Analysis of the material available has, however, not revealed any correlation of the kind. This is very important because it shows that

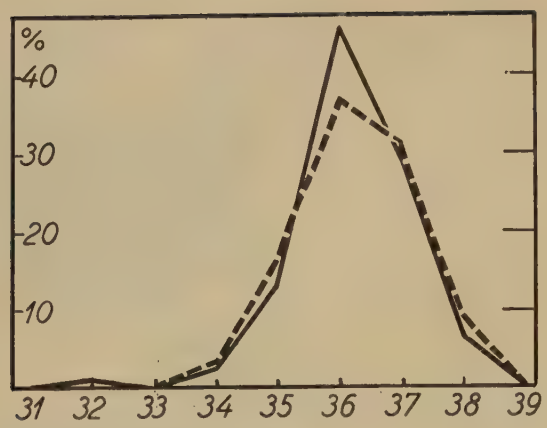


Figure 2. Size distribution of all herring measured in North Iceland in 1953 (—) and of the herring tagged there during the same season (-----).

there must be a factor which deprives the early starting herrings of their advantage and evens out, by some means, the handicap of the late starters. This factor is no doubt the temperature boundary in the eastern part of the Norwegian Sea, where the ripening herrings spend some weeks in the relatively cold water, before they penetrate into the warmer water masses to find their way to the spawning ground off the Norwegian coast. This has been proved by Finn Devold. The herrings accumulate at this barrier, where they have to wait until a physiological impulse compels them to make a new start for the spawning grounds. What this new impulse is we do not know, but it is certainly correlated with the activity of the interstitial cells of the gonads in one way or other.

6. The Migrations from Norway to Iceland.

If we consider Figure 1, it is striking that many more of the herrings which have been tagged at Iceland are returned from Norway than from Iceland. If we also consider the relatively few Norwegian tags we have found in Iceland it might seem that the migrations have a rather one-way trend, as they seem to indicate a large-scale movement from Iceland to Norway, and but few fish going in the opposite direction. This is, however, not true, as will be seen if we take the quantity of fish caught, on one side, and the number of tags returned from each country on the other side into consideration. We can confine ourselves to considering the last four years, 1951—54, during which the magnet-systems in the processing plants of both countries have worked in a satisfactory way. During this period 30.6 million hectolitres have been processed in Norway, and only 945,000 hl. in Iceland. Considering now the Norwegian taggings we find that 861 tags have been returned, if we disregard tags returned during the season of taggings, which give no information as to

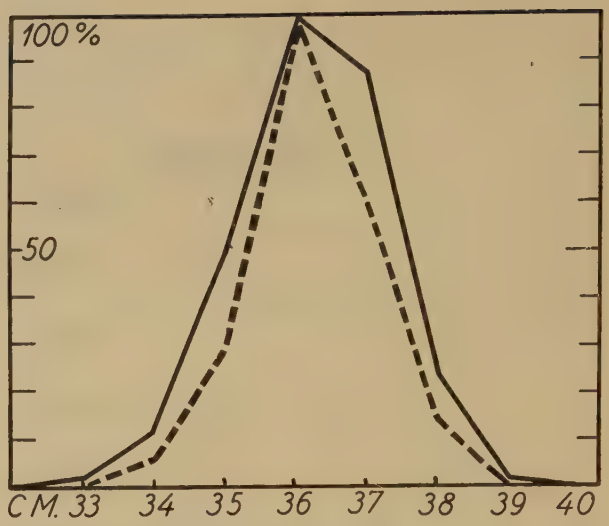


Figure 3. Size distribution of herring tagged off North Iceland in 1953 (—) and of the herring from that tagging returned in Norway in 1954 (-----).

transatlantic migrations. The average number of Norwegian tags per 1,000,000 hl. processed in Norway is therefore 28.2, and the average number of Norwegian tags per 1,000,000 hl. produced in Iceland is 7.4 which shows very clearly that the density of herring tagged in Norway in the herring stock of North Iceland is 26 % of the density on the spawning grounds at Norway. In the case of Iceland we find 213 tags of Icelandic origin in a million hectolitres of herring processed in Iceland, the corresponding figure for Norway being 36.1 herring from Iceland or 17 %. It seems therefore that the trend of migration from Norway to Iceland is quite as well pronounced as the trend of migration towards Norway (Figure 4). The reason why we get so few Norwegian tags, must therefore be explained by other means than a one-way migration of the herring. It is firmly connected with the poor fishing in north Icelandic waters during recent years, which in turn is due to the fact that the herring, during its migration from Norway, does not go sufficiently far westwards to reach the north coast banks in any quantity worth mentioning. This theory cannot be proved to-day, but it will be proved as soon as there is a new period of good herring fishing at North Iceland.

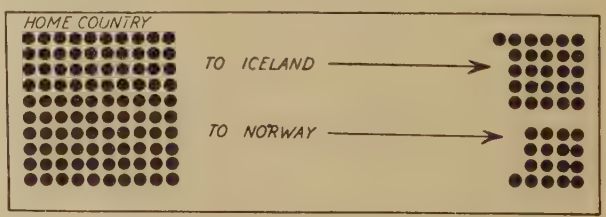


Figure 4. Relative densities of tagged herring.

6.

Swedish Herring Tagging Experiments, 1949—1953.

By Hans Höglund

Introduction.

The Swedish herring tagging work started with a tentative trial in March 1949 (see Rapp. et Proc.-Verb., Vol. 128, 1951, p. 52) and since then it has been continued every year.

This report is intended to be only a brief account giving the main points of our tagging work and the results obtained. A more comprehensive paper on the subject is in preparation for publication at a later date.

The Technique.

The tag used by us has been, without any exception, the Lea hydrostatic tag. It is attached to the back of the fish by a stainless steel wire hinge consisting of a U-shaped link articulating with a transverse rod (see fig. on p. 276 in Journ. du Cons., Vol. XIX, No. 2, 1953). In one experiment, however, a simplified method of attachment was tried for the purpose of comparing it with the usual one. The efficiency of this simplified method proved to be very low and it was therefore abandoned.

An essential part of the Swedish technique is that length measurements are made and scale samples taken in connexion with the tagging operation.

As an absolute minimum a team of two men is needed to carry out the tagging, but, since the work is usually made on board a research vessel, more men as a rule are engaged. With a team of five men the tagging speed can reach a maximum of 60 fish an hour.

When operating in the archipelago of the eastern Skagerak we have taken the live herring from pound-nets; on the other hand the live herring were trawl-caught in the North Sea experiments. On practically every tagging expedition we have suffered from a constant shortage of live fish. This fact, not the meticulous tagging technique, has been the main restrictive factor in our tagging work.

The Taggings.

The tagging experiments have been executed twice yearly; firstly in late winter and/or early spring in the archipelago of the northern west coast of Sweden, i.e., eastern Skagerak; secondly in late summer and/or early autumn in the North Sea.

During the five years 1949—53 a total of 8991 herrings has been tagged out of which 6465 were released in the eastern Skagerak and 2526 in the western North Sea. Owing to the difficulty of getting sufficient supplies of live fish we have mostly had to be content with what we could get. Rarely have we been able to make any selection from the catches and consequently the composition of our releases will be mostly of the same mixture as in the catches with regard to herring types and year-classes. Thanks to the length measurements, the scale samples, the notes regarding the maturity stage, (so far as this can be seen externally), and, of course, the recaptured fish, there is a possibility of establishing, at least approximately, what kind of herring we have liberated. Such data are necessary when it comes to estimating the percentage recoveries of each separate type and year-class.

In the following section a very brief survey of the various experiments will be given, beginning with those made in the eastern Skagerak. A summary of the liberations is given in Tables 1 and 2.

Table 1.
Liberations and Returns from Tagging Experiments in the Northern Bohuslän Area.

Experiment No.	Year	Month	Number liberated	Number recovered 30.6.54
1	1949	March	525	23
3	1950	February-March	1016	155
		April-May	800	72
5	1951	April-May	1164 + 499[1])	187 + 26
7	1952	March-May	461	82
9	1953	March-April	2000	318
		Total	5966 + 499	837 + 26
		Sum total.....	6465	863

[1]) 499 fish were tagged by the simplified attaching method.

Taggings in the northern Bohuslän Archipelago (see Table 1).

Experiment No. 1. (See Rapp. et Proc.-Verb., Vol. 128, 1951, p. 52) was carried out on board R/S "Skagerak" during the period 4—14. March. The first batch of 153 fish was caught in set-nets and thus formed an exception to the rest of this as well as to all subsequent eastern Skagerak experiments in which pound-net-caught live herring were used. The number of tagged herring amounted to 525, of which about half were spring spawners and half autumn spawners. This is, however, a very rough computation, since the method of taking length measurements and scale samples was not introduced until the second half of the experiment.

Experiment No. 3 in 1950 was divided into two periods: the first one lasting from 10. February to 23. March 1950, inclusive, the second from 26. April to 5. May 1950, inclusive.

During the first period, when the taggings were made from R/S "Skagerak" a total of 1016 fish were liberated, out of which approximately 67 % were spring spawners, 29 % autumn spawners, and 4 % indefinable.

In the second period when the work was carried out from a landing-stage, 800 fish were liberated. This time the autumn spawners predominated making 67 %; the spring spawners made 29 %, and 4 % were indefinable.

In the middle of March Dr. E. Bertelsen from Denmark paid us a visit on board the "Skagerak". His intention was to make taggings with the Danish flag tag simultaneously with our tagging with the Lea tag in order to compare the two methods. Unfortunately, the all too few days he had at his disposal coincided with a period of very meagre supply of live herring so our joint experiment was somewhat of a failure.

Experiment No. 5, 1951, took place during the period 11. April—9. May. For this experiment R/S "Eystrasalt" was used. In all 1663 tagged herring were liberated outside the archipelago of northern Bohuslän. The distribution was approximately: 74 % autumn spawners, 23 % spring spawners, and 3 % indefinable. It was this year that the simplified method of attaching the tag was applied on 499 fish. Thus in reality only 1164 herrings were tagged by our ordinary method.

Experiment No. 7, 1952. This year the tagging was carried out also from "Eystrasalt" firstly on two occasions in March, the 12th and the 26th, secondly in the period from 17. April to 5. May, inclusive. Unfortunately, the catches in the pound-nets all through this experiment were remarkably small and the total number of releases amounted to 461 only, of which about 76 % were spring spawners and 24 % autumn spawners.

The scarcity of live herring, particularly during the second period, was all the more regrettable as Mr. B. B. Parrish from Aberdeen had joined us on "Eystrasalt" in order to perform comparative taggings with the Scottish one-man toggle. Our joint experiment thus comprised 475 liberated fish only out of which 238 were Scottish-tagged and 237 Swedish-tagged.

Experiment No. 9, 1953, was carried out from "Eystrasalt" during the period March—April (13. March—29. April). The live herring supply this year was fairly good and exactly 2000 tagged herring were liberated, about 64 % spring spawners, 34 % autumn spawners, and about 2 % indefinable.

Taggings in the North Sea (see Table 2).

Experiments No. 2, 4 and 6 were all carried out in the Fladen Ground area in August 1949, August—September 1950, and August—September 1951. In 1949 and 1951 R/S "Skagerak" was used but in 1950 we had at our disposal only a small fishing cutter, not very suitable for herring trawling. On the whole we had very bad luck in these three experiments so the liberated herrings were not numerous, being 399, 124 and 464 respectively, and not in the very best condition.

Table 2.
Liberations and Returns from Tagging Experiments in the North Sea.

Experiment No.	Year	Month	Area	Number liberated	Number recovered 30.6.54
2	1949	August	Fladen Gr.	399	2
4	1950	Aug.-Sept.	Fladen Gr.	124	2
6	1951	Aug.-Sept.	Fladen Gr.	464	3
8	1952	Sept.-Oct.	Dogger Bk.	498	11
10	1953	September	Fladen Gr.	128	3
		Sept.-Oct.	Dogger Bk.	913	28
			Total...	2526	49

Experiment No. 8, 1952, was carried out from the "Skagerak" in the Dogger Bank area, mainly in the vicinity of Outer Rough, during the period 29. September—17. October which, unfortunately, coincided with a period of mainly very unfavourable weather. 498 herrings were tagged, all of them probably were autumn spawners.

Experiment No. 10, 1953, was divided into two

parts: the first on three days at the beginning of September, the 5., 7., and 8., and the second during the period 17. September—8. October. During the first period taggings were carried out SW. of Fladen Ground and the intention was to concentrate upon spent herring. Owing to bad luck with the weather, only 128 fish were liberated. The second period was spent in the Dogger Bank area and this time conditions were favourable. When 913 fish were liberated our supply of tags was used up and the taggings had to be stopped. All taken together the liberations thus amounted to 1041 in this experiment.

Technical Results.

A very brief survey of the recoveries from the various experiments is given in Tables 1 and 2.

A more comprehensive review of the results is given in Tables 3—9. In these, recaptures from all experiments, with the exception of Nos. 2, 4 and 6, are listed with regard to time at liberty and distance between the point of liberation and the place of recapture.

The experiments 2, 4 and 6 on the Fladen Ground in 1949, 1950, and 1951 did not result in more than 2, 2, and 3 recaptures respectively, and these were made not very far from the point of liberation.

Table 3.
Recaptures from Experiment No. 1, March 1949, Northern Bohuslän; 525 liberated.

Days at liberty \ Distance naut. miles	0–10	11–20	21–50	51–100	101–150	151–200	201–250	251–300	301–350	Total	Sum total as %
0–10	1	—	—	—	—	—	—	—	—	1	0·2
11–20	1	—	—	1	—	—	—	—	—	2	0·6
21–30	1	—	1	—	—	—	—	—	—	2	1·0
31–50	3	—	—	—	—	—	—	—	—	3	1·5
51–100	—	—	1	—	—	1	—	—	—	2	1·9
101–150	—	—	2	—	—	—	—	—	1	3	2·5
151–200	—	—	1	1	1	—	—	—	2	5	3·4
201–250	—	—	—	—	—	—	—	—	—	—	—
251–300	—	—	1	—	—	—	—	—	—	1	3·6
301–350	—	—	—	—	—	—	—	—	—	—	—
351–400	—	—	—	—	—	—	—	1	—	1	3·8
401–450	—	1	—	—	—	—	—	—	—	1	4·0
451–500	—	—	—	—	—	—	—	—	—	—	—
501–550	—	—	—	—	—	—	—	1	—	1	4·2
..											
1001–1050	—	—	—	1	—	—	—	—	—	1	4·4
Totals	6	1	6	3	1	1	—	2	3	23	4·4

Table 4.
Recaptures from Experiment No. 3, late February—early May, 1950, Northern Bohuslän; 1816 liberated.

Days at liberty \ Distance naut. miles	0–10	11–20	21–50	51–100	101–150	151–200	201–250	251–300	301–350	351–400	401–450	?	Total	Sum total as %
0–10	3	4	3		1								11	0·6
11–20	4	1	3	—									8	1·0
21–30	3	1	4	—	—	—	—	—	—	—	—	—	8	1·5
31–50	7	1	12	4	1	—	—	—	—	—	—	1	26	2·9
51–100	3	3	28	5	1	—	—	—	—	—	—	—	40	5·1
101–150	—	—	2	3	—	2	—	—	4	3	1	—	15	5·9
151–200	—	1	6	1	1	1	—	—	2	4	2	1	19	6·4
201–250	1	2	5	4	1	—	—	—	2	—	1	—	16	7·9
251–300	1	2	6	8	—	—	—	—	—	—	—	2	19	8·9
301–350	—	3	4	3	—	—	1	—	—	—	—	1	12	9·6
351–400	1	1	8	1	—	—	—	—	—	—	—	1	12	10·2
401–450	1	—	5	3	—	—	—	—	—	—	—	1	10	10·8
451–500	—	—	2	3	1	—	—	—	1	—	—	—	7	11·2
501–550	—	—	—	1	—	—	—	—	1	—	1	—	3	11·3
551–600	—	—	1	1	—	—	—	—	—	—	—	—	2	11·4
601–650	—	—	1	2	—	—	—	—	—	—	—	—	3	11·6
651–700	—	—	1	—	—	—	—	—	—	—	—	—	1	11·7
701–750	—	1	1	1	1	—	—	—	—	—	—	1	5	11·9
751–800	—	—	2	—	—	—	—	—	—	—	—	—	2	12·0
801–850	—	—	2	—	—	—	—	—	—	—	—	—	2	12·2
851–900	—	—	—	—	1	—	—	—	1	—	—	—	2	12·3
901–950	—	—	1	—	—	—	—	—	—	—	—	—	1	12·3
951–1000	—	—	—	—	—	—	—	—	—	—	—	1	1	12·4
..														
1251–1300	—	—	1	—	—	—	—	—	—	—	—	—	1	12·4
1301–1350	—	—	1	—	—	—	—	—	—	—	—	—	1	12·5
Totals	24	20	99	40	8	3	1	—	11	7	5	9	227	12·5

Table 7. Recaptures from Experiment No. 8, late September—early October 1952. Dogger Bank; 498 liberated.

Days at liberty	Distance naut. miles 0–10	11–20	21–50	51–100	101–150	151–200	201–250	251–300	?	Total	%
0—10	1	3	—	—	—	—	—	—	1	5	1·0
11—20	—	—	1	—	—	—	—	—	2	3	1·6
21—30	—	—	—	1	—	—	—	—	—	1	1·8
313	—	—	—	—	—	1	—	—	—	1	2·0
492	—	—	—	—	—	—	—	1	—	1	2·2
Total	1	3	1	1	—	1	—	1	3	11	2·2

Table 5. Recaptures from Experiment No. 5, April—early May 1951, Northern Bohuslän. 1

Distance naut. miles	0—10		11—20			21—50			51—100			101—150		151—200	2
Days at liberty	A	B	A	B	C	A	B	C	A	B	C	A	B	A	
0—10	—	1	2	1	—	1	2	-	—	—	—	—	—	—	
11—20	-	—	—	2	—	3	4	1	1	—	—	—	—	1	
21—30	—	—	—	—	1	6	6	2	1	—	—	1	—	-	
31—50	—	1	2	—	1	5	2	—	—	1	1	—	1	—	
51—100	—	1	—	—	—	5	7	1	17	5	8	—	—	—	
101—150	—	—	1	1	—	2	—	—	10	4	3	—	1	—	
151—200	—	—	1	2	—	4	2	—	1	2	—	—	1	—	
201—250	—	1	—	1	—	—	—	—	1	—	—	—	—	—	
251—300	—	—	1	3	—	4	—	—	—	—	1	—	—	—	
301—350	1	4	—	—	2	3	1	1	2	2	—	—	—	-	
351—400	—	—	1	1	—	1	7	1	1	1	—	—	1	-	
401—450	-	—	—	—	—	1	1	—	1	1	—	—	—	—	
451—500	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
501—550	—	—	—	—	—	—	—	—	1	—	—	—	1	—	
551—600	1	—	—	—	—	—	—	—	—	—	—	—	—	—	
601—650	—	—	-	—	—	—	—	-	-	—	—	—	—	—	
651—700	—	—	—	—	—	—	—	—		1	—	—	—	—	
701—750	—	—	—		—	—	—	—	—	—	—	—	—	—	
751—800	—	—	—	—	—	-	—	—	—	1	-	—	—	—	
801—850	—	—	—	—	—	—	—	—	—	—	-	—	—	—	
851—900	—	—	1	—	—	—	—	-	—	—	—	—	—	—	
901—950	—	—	—	—	—	—	—	—	-	—	—	—	—	—	
951—1000	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
1001—1050	—	—	—	—	—	—	—	—	1	—	—	—	—	—	
1051—1100	—	-	—	—	-	—	—	—	—	—	—	—	—	—	
1101—1150	—	—	—	1	—	—	—	—	—	—	—	—	—	—	
Total: A	2	—	9	—	—	35	—	—	37	—	—	1	—	1	
— B	—	8	—	12	—	—	32	-	—	18	—	—	5	—	
— C	—	—	—	—	4	—	—	6	—	—	13	—	—	—	

	Liberated		Recaptured	
A: Tagged by the ordinary method, 11/4—26/4-51 and 7/5—9/5-51:	665	1164	101 = 15·2 %	187 = 16
B: Tagged by the ordinary method, 27/4—7/5-51:	499		86 = 17·2 %	
C: Tagged by the simplified method, 27/4—7/5-51:	499		26 = 5·2 %	

Table 8. Recaptures from Experiment No. 9, March-April 1953. Northern Bohuslän; 2000 liberated.

Days at liberty	Distance naut. miles													
	0–10	11–20	21–50	51–100	101–150	151–200	201–250	251–300	301–350	351–400	401–450	?	Total	%
0—10	19	5	3	—	—	—	—	—	—	—	—	—	27	1·3
11—20	9	6	1	4	—	—	—	—	—	—	—	—	20	2·3
21—30	5	3	7	4	—	—	—	—	—	—	—	—	19	3·3
31—50	5	3	9	3	-	—	—	—	—	—	—	—	20	4·3
51—100	—	5	13	6	2	—	—	—	—	—	—	1	27	5·6
101—150	—	1	14	7	—	3	—	1	4	1	1	2	34	7·3
151—200	3	9	12	4	—		—	1	—	3	4	3	39	9·3
201—250	3	12	12	1	—	—	—	-	—	—	—	1	29	10·75
251—300	1	1	6	5	—	—	—	—	—	—	—	1	14	11·45
301—350	2	—	6	4	—	—	—	1	—	—	—	5	18	12·35
351—400	7	12	26	9	2	—	—	—	—	—	—	—	56	15·15
401—450	–	—	11	4	—	—	—	–	—	—	—	—	15	15·9
Total	54	57	120	51	4	3	—	3	4	4	5	13	318	15·9

Herrings tagged by the ordinary attaching Method; 499 Herrings tagged by the simplified Method.

51—300	301—350			351 400			401	450	501	550	?		Total			Sum total as %		
A	A	B	C	A	B	C	A	B	A	A	B	A	B	C	A	B	C
—	—	—	—	—	—	—	—	—	—	—	—	3	4	—	0·4	0·8	0
—	—	—	—	—	—	—	—	—	—	—	—	5	6	1	1·2	2·0	0·2
—	—	—	—	—	—	—	—	—	—	—	—	8	6	3	2·4	3·2	0·8
—	—	—	—	—	—	—	—	—	—	—	—	7	5	2	3·4	4·2	1·2
—	1	—	—	—	—	—	—	—	—	—	1	23	14	9	6·9	7·0	3·0
—	2	2	1	1	1	1	1	1	—	1	—	18	10	5	9·6	9·0	4·0
1	3	3	—	—	—	—	2	1	1	1	—	14	11	—	11·7	11·2	4·0
—	1	—	—	—	—	—	—	—	—	—	—	2	2	—	12·0	11·6	4·0
—	—	—	—	—	—	—	—	—	—	—	—	5	3	1	12·8	12·2	4·2
—	—	—	—	—	—	—	—	—	—	—	—	6	7	3	13·7	13·6	4·8
—	—	—	—	—	—	—	—	—	—	—	—	3	10	1	14·1	15·6	5·0
—	—	—	—	—	—	—	—	—	—	—	—	2	2	—	14·4	16·0	5·0
—	—	—	1	—	—	—	—	—	—	—	—	—	1	1	14·4	16·2	5·2
—	—	1	—	—	—	—	—	—	—	—	—	1	2	—	14·6	16·6	5·2
—	—	—	—	—	—	—	—	—	1	—	—	2	—	—	14·9	16·6	5·2
—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	14·9	16·8	5·2
—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	14·9	17·0	5·2
—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	15·0	17·0	5·2
—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	15·2	17·0	5·2
—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	15·2	17·2	5·2
1	7	—	—	1	—	—	3	—	2	2	—	101	—	—	15·2	—	—
—	—	6	—	—	1	—	—	2	—	—	1	—	86	—	—	17·2	—
—	—	—	2	—	—	1	—	—	—	—	—	—	—	26	—	—	5·2

Table 9. Recaptures from Experiment No. 10, September-October, North Sea (Fladen Ground, Dogger Bank); 1041 liberated.

Days at liberty	Distance naut. miles											
	0–10	11–20	21–50	51–100	101–150	151–200	201–250	251–300	301–350	?	Total	%
0—10	2	—	2	3	—	—	—	—	—	—	7	0·7
11—20	—	—	—	3	—	—	—	—	—	3	6	1·2
21—30	—	—	1	—	—	1	—	—	—	2	4	1·6
31—50	—	—	—	—	—	1	—	1	—	—	2	1·8
51—100	—	—	—	—	—	—	—	3	—	—	3	2·1
101—150	—	—	—	—	—	—	—	1	5	1	7	2·8
151—200	—	—	—	—	—	—	—	1	—	—	1	2·9
201—250	—	—	—	—	—	—	—	—	1	—	1	3·0
Total	2	—	3	6	—	2	—	6	6	6	31	3·0

Table 6. **Recaptures from Experiment No. 7, March—early May 1952, Northern Bohuslän. 461 Swedish-tagged and 341 Scottish-tagged Herrings liberated.**

Distance naut. miles	0—10			11—20				21—50			51—100			101—150			151—200	301—350	501—550	?		Total			
Days at liberty	Sw.		Sc.	Sw.		Sc.		Sw.		Sc.	Sw.		Sc.	Sw.		Sc.	Sw.	Sw.	Sw.	Sw.	Sc.	Sw.		Sc.	
	a	b	a	a	b	a	b	a	b	a	a	b	a	a	b	a	a	b	b	b	a	b	a	b	a	b
0—10	–	3	–	-	1	–	1	—	1	—	—	—	—	—	—	—	—	–	—	—	1	2	—	5	1	3
11—20	—	2	1	—	1	1	—	—	—	–	—	–	—	—	—	—	—	—	—	1	—	1	—	4	2	1
21—30	1	2	1	1	1	—	—	—	1	–	–	—	—	—	—	—	—	—	—	—	—	–	2	4	1	—
31—50	—	—	2	—	1	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	–	—	3	1	2	—
51—100	—	1	2	1	—	1	—	5	7	1	-	1	1	—	—	—	1	—	—	—	1	2	7	9	6	2
101—150	—	–	—	—	—	—	—	1	—	1	2	—	1	1	1	1	—	–	—	—	2	–	4	1	5	—
151—200	-	1	—	—	3	—	1	—	1	—	—	—	—	—	—	—	1	—	1	–	—	1	1	6	—	2
201—250	—	-	—	1	1	–	1	1	2	—	–	—	–	—	—	—	—	1	—	—	1	—	2	4	1	1
251—300	—	—	—	2	—	—	—	1	—	—	—	—	—	—	—	–	—	–	—	—	—	—	3	—	—	—
301—350	—	1	-	1	1	—	—	1	2	–	2	2	—	—	—	—	—	—	—	—	—	–	4	6	—	—
351—400	3	—	–	—	1	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—	—	4	2	—	—
401—450	—	—	—	—	—	—	—	1	1	—	—	—	–	—	—	—	—	—	—	—	—	—	1	1	—	–
451—500	—	—	—	-	—	—	—	1	1	—	—	1	—	—	—	—	–	—	-	—	—	—	1	2	—	—
501—550	—	-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
551—600	—	–	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
601—650	—	–	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	-	—	—	—	—	—	—	—	—
651—700	—	—	—	—	—	—	—	—	—	-	—	–	—	–	—	—	—	–	—	—	—	—	—	—	—	—
701—750	1	—	—	—	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
751—800	—	—	—	—	—	—	—	—	2	-	—	—	—	—	—	–	—	—	–	—	—	—	1	2	—	—
																								2	—	—
Total: Sw. a	5	—	—	6	-	—	—	15	—	—	4	—	-	1	—	—	2	—	—	—	—	—	33	—	—	—
— Sw. b	—	10	—	—	11	—	—	—	18	—	-	6	–	—	1	—	—	1	1	1	—	—	–	49	—	—
— Sc. a	—	—	6	—	—	2	-	—	—	2	—	—	2	-	—	1	—	—	–	—	5	—	—	—	18	—
— Sc. b	—	-	—	—	—	—	3	—	—	—	—	—	—	—	—	-	—	—	—	—	—	6	—	—	—	9

	Liberated		Recaptured	
Sw. a: Recaptures from Swedish taggings *before* and *after* the joint experiments	224	461	33 = 14·7 %	82 (17·8 %)
Sw. b: Recaptures from the Swedish part of the *joint* experiment	237		49 = 20·67 %	
Sc. a: Recaptures from the Scottish part of the *joint* experiment	238	341	18 = 7·6 %	27 (7·9 %)
Sc. b: Recaptures from Scottish taggings *after* the joint experiments	103		9 = 8·7 %	

Time at Liberty.

For the sake of clarity Table 10 gives a summary of the days at liberty for all recoveries from the experiments carried out in the eastern Skagerak district.

Table 10.

Experiment No.	Year	Number of fish liberated	Nos. of fish recaptured within the following days at liberty 0–350	351–750	751–1100	<1100	Total No. recovered
1	1949	525	19	3	1	—	23
3	1950	1816	174	43	8	2	227
5	1951	1663	183	26	3	1	213
7	1952	461	66	14	2	—	82
9	1953	2000	247	71	—	—	318
	Total...	6465	689	157	14	3	863

The comparatively high number of long-time recoveries gives an idea of the survival of the tagged fish, and consequently of the efficiency of the tagging method.

Bleeding.

Through the attaching of the tag the bloodvessels in the back of the fish are often damaged, thus causing a more or less heavy haemorrhage from the tag wound. In order to ascertain the influence of the bleeding upon the rate of survival notes were made in the last half of experiment No. 9, 1953, about the "bleeders" and "non-bleeders". Out of 1090 fish liberated 673 were "non-bleeders" and 417 were "bleeders". Up to 30. June 1954 12.3 % of the "non-bleeders" and 10.6 % of the "bleeders" were recaptured. These figures indicate that bleeding is by no means as fatal as might be expected.

Manner of Recovery.

The tags are intended to be as conspicuous as possible, and for several reasons the purpose of the tagging experiments will naturally be best served when the recaptures are discovered by the fishermen at the time of the catch. Fortunately, this has also been the case in the majority of our recapture. But sometimes it happens that the tagged fish passes unobserved through several hands before it is discovered.

In our records the finders of the tags are divided into four main categories: (1) fishermen, (2) wholesalers, curers etc., (3) retailers, and (4) consumers, and in Table 11 the percentages in which the recoveries have been made by the various categories are given. The figures are based upon the total number of 912 returned tags.

Tag + Fish or Tag only.

We are, of course, very anxious that not only the tag but also the fish is returned to us. Unfortunately, the number of tags returned without fish is rather high amounting to about one third of the total (see Table 11). In some cases the wrong herring has been

Table 11.

Finders	Tag + fish %	Tag only %	Total %
Fishermen	59·2	28·1	87·3
Wholesalers	3·4	1·2	4·6
Retailers.....	4·1	1·5	5·6
Consumers	1·2	0·9	2·1
Others.....	—	0·4	0·4
	67·9	32·1	100·0

sent with the tag. As a rule this has been done unintentionally, but in a few cases deliberate falsifications have been disclosed.

Type of Gear.

Recaptures have been made by many different types of gear. The following list gives the relative frequency of the various fishing gear, by which recaptures have been made in our tagging experiments. The percentage figures are computed from the total number of 912 recaptures:—

		%
1.	Herring bottom trawl.....	30·8
2.	Mackerel drift-net	19·8
3.	Herring set-net.....	16·5
4.	Purse-seine.....	4·3
5.	Pound-net	4·2
6.	Pelagic trawl.....	4·0
7.	Shore-seine.....	3·5
8.	Set-net for flatfish, cod, etc.	3·3
9.	Fish trawl	2·7
10.	Ripper & "häckla"	2·1
11.	Prawn trawl	1·1
12.	Herring drift-net	1·1
13.	Mackerel set-net.....	0·7
14.	Danish seine	0·4
15.	Unknown	5·5
		100·0

As to *the nationality of the finders* the recaptures are distributed as follows:—

		%
1.	Swedish.....	64·0
2.	Norwegian	14·9
3.	Danish	9·5
4.	German.....	7·3
5.	Dutch	1·9
6.	French	1·1
7.	English	0·5
8.	Scottish.....	0·4
9.	Belgian	0·3
10.	Greek	0·1
		100·0

Comparison between Scottish and Swedish Methods.

In April 1952 Mr. Parrish and I arranged a joint experiment in order to compare the relative merits of the two different methods used in Scotland and Sweden. The catches of live herring from pound-nets were divided into two parts as equal as possible with regard to number and size of fish and were shared evenly between us. The handling of the fish before and after the tagging procedure was exactly the same.

Details concerning the recoveries up to 30. June 1954 are given in Table 6. From the joint experiment, 18 (7.56 %) of the Scottish tags and 49 (20.67 %) of the Swedish tags were recovered; that is to say: the Swedish method turned out to be 2.7 times as effective as the Scottish one.

The cause for one method being more efficient than another may be threefold. Firstly, some part of the cause may be found in the tags themselves. With regard to this point I cannot enter upon a comparison, but it must be stressed that the Lea tag has the very great advantage of containing a letter in which full instructions are given to the finder about the purpose of the tagging and how to deal with the find.

Secondly, the cause may be sought in the attaching gear. Here two factors are important: the possibility of the tag being shed from the still living fish and the possibility of the tag gradually bringing about a lethal injury to the fish.

Thirdly, the handling of the fish during the tagging operation must be of great importance. In the Scottish method the operator grasps the fish with the bare hand. In the Swedish method the touching of the fish by human hand is avoided as far as possible and the fish is kept constantly in circulating sea water.

The Scottish method is beyond comparison much quicker than the Swedish. One single trained operator is able to tag 3—4 herrings by the Scottish method within the same time as a Swedish team of 4—5 man are tagging one fish. Consequently the Scottish method is several times cheaper than the Swedish.

One must, however, take into consideration that the length measurements, the taking of scale samples and the necessary recording are factors by which the working speed is greatly delayed. These factors do not exist in the Scottish method. The information about the liberated fish given by this extra burden of work is, in my opinion, so valuable that the reduction of the tagging rate is compensated many times over.

When estimating the relative merits of different tags and different attachments one must, of course, take into account the field-conditions under which the tagging work is intended to be executed. It is, for instance, quite out of the question to use the Swedish manner of tagging on a commercial fishing boat.

Biological Results.

The purpose of the tagging experiments is first and foremost to obtain information about the migrations of the herring. Secondly, one might expect to get at least some hints about the fisheries' taxation of the herring stocks.

Furthermore the experiments, as applied by us in Sweden, have yielded valuable information as to the rate of growth of the herring or, more correctly, the growth-rate of the herring scales.

Migrations.

In this report I shall restrict myself mainly to discussing very briefly the long-distance migrators to, within, and from the North Sea. Reference is made to Charts 1 and 2. It must be noticed that most of the long-distance migrators to the open North Sea have been autumn spawners. None could be identified with absolute certainty as a spring spawner.

As will be seen from Chart 1, recoveries from the eastern Skagerak experiments are distributed almost all over the whole North Sea, from Walker Bank in the north to Dover Strait in the south. The distribution is not even, however, showing instead a grouping on the most prominent herring fishing grounds. Table 12 shows how the recoveries on the various grounds are scheduled in accordance with the seasonal changes in herring fishery.

In Chart 2 the recoveries from the 1952 and 1953 experiments in the North Sea are plotted. These, too, exhibit the same kind of grouping, and, as is shown in Table 13, they follow the same time-table.

There are several striking features to be found when studying Charts 1 and 2 and Tables 12 and 13. Most unexpectedly for instance, at least to me, is the indication of a herring communication between the Skagerak and the Sandettié area. Another interesting feature, though negative, is, that not a single recapture from the liberations in the Skagerak has been made by the Scottish drift-net fishery.

The charts in connexion with the "time-tables" indicate fairly clearly that the main part of the stocks of autumn-spawning herring in the North Sea is involved in a huge counter-clockwise circular movement with one revolution yearly.

Table 12.

"Time-table" for 77 of the recoveries in the North Sea from experiments Nos. 1, 3, 5, 7, & 9 (1949—1953), see Chart I.

Area of recapt.[1] / Months	Egersund Bank	Fladen Ground	The Gut	Dogger Bank	Off Whitby	West Hole	Sandettié	Off Hanstholm
July	—	1	—	—	—	—	—	—
August	5	8	—	—	—	—	—	
September	2	4	4	16	3	—	—	—
October	—	—	1	22	1	—	—	1
November	—	—	—	4	—	1	3	—
	7	13	5	42	4	1	3	1

[1]) 1 recapture in January at Horns Reef.

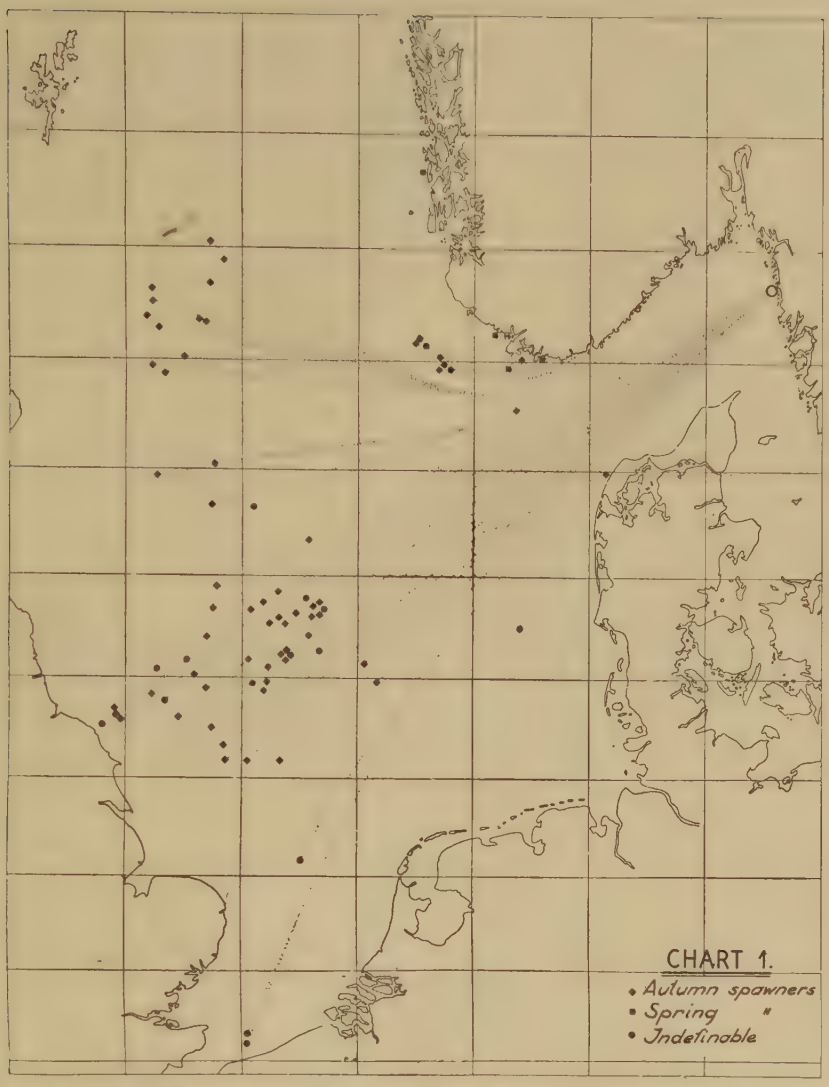


Chart 1. Migrations from Skagerak to the North Sea. In this chart 80 recaptures in the North Sea from experiments Nos. 1, 3, 5, 7 and 9 (1949—1953) are plotted, whose positions of recapture are known for certain. The numerous recaptures in Skagerak and Kattegat are omitted.

The detailed route of each separate recaptured fish cannot, of course, be traced in the charts. To this extent the dotted lines between the places of liberation and recovery are misleading. It is not likely, for instance, that the three migrators from Skagerak to Sandettié should have taken the straight course indicated in Chart 1, or that the fish in Chart 2 that was liberated on the Dogger Bank in the autumn of 1952 should have moved straight away to the Fladen Ground where it was refound in August 1953.

For various reasons the three herrings liberated SW. of Fladen Ground and recaptured in the Skagerak deserve particular mention. All three were tagged on 7. September 1953 at 57°46′ N., 0°08′ E. and were recorded as indubitable spents, thus probably belonging to the herring stock which spawn in August and September not far from the place of tagging. Two of them were recaptured north of Jutland on 2. and 3. February 1954; but the third was recaptured 15 miles west of the middle Bohuslän as late as 3. May.

As already mentioned, we were, in the 1953 experiment in the Fladen Ground area deliberately on the look-out for spents in order to make an attempt at unravelling the movements of this type of herring. So far, we were fortunate as this type could be proved to take part in the wintering in the Skagerak; but the migration route still remains to be explored.

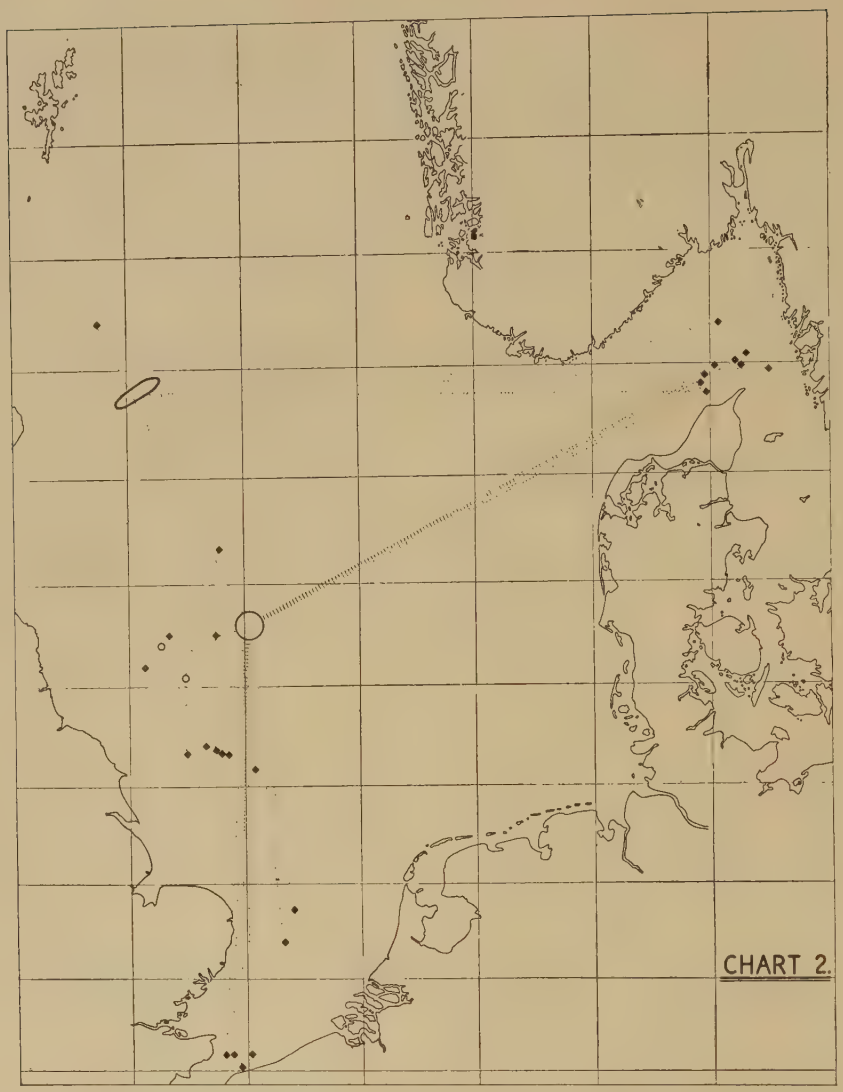


Chart 2. Recaptures from the Dogger Bank taggings 1952 (experiment No. 8) and from the Fladen Ground and Dogger Bank taggings 1953 (experiment No. 10). (In addition to the 26 recaptures plotted in the chart there were 16 more returns from these experiments whose points of recapture were within the area of liberation or else not precisely established).

Fisheries Taxation.

In some of our experiments in the Skagerak the rate of recapture has been surprisingly high, in several cases between 15 and 20 %; and as these are only minimum figures the taxation of the stock from the part of the fishery must be considerable. The taxation does not work indiscriminately, however, for the chances of being recaptured are widely different not only for different types of herring but also for different age-groups of the same stock.

The recoveries of spring spawners are, comparatively, much more numerous than those of autumn spawners. The first part of experiment No. 3, 1950, for instance, when the spring spawners predominated in the releases, yielded a recovery of 15.2 % while, on the other hand, the second part, when the autumn spawners predominated, yielded only 9.0 %.

As an example of the differences in the rate of recovery of the various age-groups some figures from experiment No. 9, 1953, may be quoted. In this experiment a total of 2000 fish were liberated of which 1293 were spring spawners, 674 were autumn spawners and 33 were indefinable.

In Table 14 the distribution of the age-groups of the spring spawners is given as well as the absolute and percentage numbers of recapture.

Table 13.

"Time-table" for 22 recoveries from experiments Nos. 8 & 10, see Chart 2.

Months / Area of recapture	Dogger Bight	Winterton Shoal	Sandettié	Skagerak	Fladen Ground
September	2				
October	4				
Nov. 1st half		2			
Nov. 2nd half	—		3		
December	—	—	1	—	
January	—	—	—	1	
February				6	
March				1	
April					
May				1	
June					
July					
August					1
	6	2	4	9	1

It should be noticed that the recoveries of the autumn spawners in the same experiment amounted to 9.3 % only.

There is no doubt that the very high rate of recapture in the youngest age-groups of the spring spawners is due to the fact that these herrings, as our tagging results show, do not generally make any long-distance movements but remain mainly within the archipelago where the fishing intensity, in places, is comparatively very high.

Table 14.
Spring Spawners in Experiment No. 9.

Number of winter-rings	Number liberated	Number recaptured	% recaptured
1	68	21	30·9
2	607	147	24·2
3	67	20	29·8
4	39	6	15·4
5	104	14	13·5
6	43	6	14·0
7	244	25	10·2
7	121	11	9·1
Total/Mean	1293	250	19·3

Rate of Growth.

As a rule the condition of the recaptured fish does not permit exact determination of length increases during the period of liberty. Usually several days have elapsed between the catch and the arrival of the fish at the laboratory and meanwhile shrinkage and putrefaction have set in. Only occasionally did we happen to be on the very spot where a tagged herring was recaught and were able to take length measurements of an absolutely fresh fish.

The advantage of being able to study the scales from one and the same fish at two different moments of its life is obvious in many respects. Above all it has proved to be useful when attempting to establish the time when the winter-rings are formed. Furthermore the scales can be used as evidence when it comes to verifying whether a returned fish is genuine or not.

Addenda.

Since this report was prepared in July 1954 some additional recaptures have been made. Up to 1. August 1955 the numbers of recoveries have increased:

in experiment	3, 1950,	by 1,[1])	making a total of	228
- —	5, 1951,	- 3,	— - —	-	216
- —	7, 1952,	- 3,	— - —	-	85
- —	8, 1952,	- 1,	-	-	12
- —	9, 1953,	- 47,	- —	-	365
- —	10, 1953,	- 4,	— - —	-	35

[1]) This fish was recaptured close upon 5 years (1771 days) after liberation.

7.

Danish Herring Tagging inside the Scaw, 1945—1952.

By Aage J. C. Jensen

During 1949—52 2796 herrings were tagged with external tags in the Kattegat, Limfjord, Sound, Belt Sea, and Western Baltic during 12 tagging experiments. 551 tags or 20 % were returned; of these 2 tags had been found on the shore and some few tags had been found in the fishing gear after being torn off the herring. One herring was caught just as the tag had been torn from the fish, evidently by the gear.

Technique of Tagging.

The tags used were the Lea hydrostatic tags and blue and red numbered oval plastic plates fastened by nylon thread; in most cases an appeal for sending in the fish was stamped on the reverse of the last named tags.

The herring were taken from pound-nets while they were being emptied by the fishermen and were transferred to the well of a small motorboat by means of a dip-net fixed on a pole. Part of the fish at one tagging experiment were taken from a commercial herring trawl before the fish were taken onboard the cutter. In some cases the herring were transferred from the well of the fishing boat to a well-box before tagging.

From the well of the motorboat or the well-box the herring were taken by a "Lea-crib" (or cradle) and tagged without or almost without being touched by the hand.

The steel needles of the Lea tags were given a sharp point by grinding; they were fixed in the special tong and thrust through the herring without using a hollow needle.

Circulating sea water was used only in the first experiment on some herring, but it was difficult and time-wasting to use on the small motorboats from which the herring were tagged, and it was abandoned. It turned out that most of the herring lay still when the crib was held sloping, and the head of the herring was covered with water. In the crib the fish could breathe without difficulty on account of its snout resting against a perforated partition-wall in the foremost funnel-shaped part of the crib. Some few herring struggled strongly and most of these were rejected for tagging, because herring may be damaged from too strong movements.

During the first experiments most of the herring had to be transported rather long distances in rough sea in order to bring them to a sheltered place where the tagging could be carried out, and no doubt this is one reason for the proportionately few recaptures at these experiments.

The localities, dates, numbers tagged and percentages of returned tags are shown in Table 1.

Bleeding.

Great care was taken to remove the scales where the needle was thrust into the herring. Heavy bleeding will result when a scale is forced into the flesh, and whenever this happened the herring was rejected.

On the other hand bleeding may be due to a blood vessel being damaged by the needle and if this bleeding was heavy the herring was rejected. In order to secure sufficient material for judging if a minor bleeding is harmful to the result, the bleeding was tabulated for all herring except at the first experiment.

The number of "bleeders" and the recaptures in the various types of fastening the tag are shown in Table 2.

The percentage of bleeders seems to be a little less for the tags fastened by soft braided nylon than for the Lea tag, but it was proportionately large for

Table 2.
Numbers and Recaptures of Bleeders.

	Lea tag	Plastic tag fastened by	
		Soft nylon	Stiff nylon
Total number	1422	702	301
Bleeders	110	35	59
% Bleeders	7·7	4·5	19·5
% Recaptures of bleeders.....	19·4	20·0	22·0
Non-bleeders	21·2	22·4	18·6

Table 1. Survey of Danish Tagging of Herring inside the Scaw.

Exper. Nos.	Month	Year		Number of herring tagged with			% Tags returned		
				Lea	blue	red	Lea	blue	red
1	Oct.	1949	Great Belt	291	—	—	6	—	—
2	„	„	S. of Copenhagen	99	—	—	13	—	—
3	April	1950	Scaw-Frederikshavn	297	—	—	8	—	—
4	Oct.	„	E. of Langeland	276	—	—	13	—	—
5	Nov.	„	At Copenhagen	133	—	—	17	—	—
6	April	1951	SW. Fyn	102	89	100	22	21	14
7	„	„	Limfjord	147	150	—	46	33	—
8	May	„	North Seeland	70	170	—	40	31	—
9	March	1952	N. of Als	75	85	86	28	14	16
10	April	„	S. of Als	76	155	75	29	26	17
11	„	„	SE. Fyn	125	74	89	24	18	16
12	Nov.	„	Copenhagen	22	—	10	23	—	10

those fixed by stiff nylon which will very easily cut into the flesh.

Yet, there is no difference between the percentage of recaptures of bleeders and of non-bleeders at each of the three types of fastening.

Loss of Scales.

In order to ascertain the importance of tagging of herring without the loss of many scales, the proportion of scales left on the fish after tagging has been observed.

This "scaledness" has been divided into 4 classes, as follows: (1) less than one tenth of the scales lost, (2) with less than about one third lost, (3) about one half lost, and (4) less than about one third of the scales left.

Naturally it is impossible to state exactly the "scaledness" of a herring when swimming in the well or when lying in the crib, and in most cases it is virtually impossible to state the amount of scales on the belly; there may also be differences from one experiment to another in the classifying of the "scaledness" although almost all of the taggings have been made by the author.

The number of herring taken for tagging from pound-nets in the four scale-classes and the recaptures by the different methods of fastening the tag are shown in Table 3.

Table 3. "Scaledness".

Scale-classes	Lea		Soft nylon		Stiff nylon	
	Nos. tagged	% recapt.	Nos. tagged	% recapt.	Nos. tagged	% recapt.
1	852	25	474	24	217	22
2	324	17	183	21	62	14
3	178	11	43	5	18	11
4	68	2	2	0	4	0
Total/Mean	1422	20	702	22	301	19

Comparison between different Types of Tags.

In the latest 6 tagging experiments different types of tags were used, 10—20 of one type alternating with 10—20 of another.

In Table 4 the results are compared for each pair of types for the experiments where they have been used together. Here we discount the various sorts of nylon thread for fastening the plastic tags:

Table 4. Comparisons of percentage Recaptures of different Types of Tags.

Month after tagging	1	2–4	5–7	8–10	11–12	Total	Number tagged
Lea tag	21·8	4·9	2·8	0·7	1·2	31·3	595
Blue plastic	19·2	3·5	1·0	0·2	0·0	23·9	723
Lea tag	10·8	6·2	5·2	1·7	1·1	25·0	400
Red plastic	8·9	4·8	1·0	0·0	0·0	14·7	360
Blue plastic	15·9	2·2	1·5	0·3	0·0	19·9	403
Red plastic	11·2	3·4	1·2	0·0	0·0	15·8	350

The percentages recaptured are means of percentages in the different tagging experiments in order to avoid errors which might arise because the proportions between the numbers tagged with the various tags are different in the 6 tagging experiments where they have been used simultaneously.

It is seen that the Lea tag has on an average given more recaptures than the blue and the red tags. In the first month after the tagging there was no difference, but after about six months very few of the herring tagged with the plastic tags were recaptured, whereas some Lea tags were found until about a year after the tagging.

No doubt more of the plastic tags are shed than of the Lea tags because the nylon thread may cut more easily through the flesh, and a contributory cause of the superiority of the Lea tag to the plastic tags is the detailed instructions in the letter in the Lea tag.

As mentioned above different sorts of nylon thread were used for fastening the plastic tags. They were: 0.2 and 0.3 mm. thick, transparent, rather stiff nylon fishing line used with the two threads of the loop either untwined or twined, and black or green, braided, soft nylon line. In the vertical columns of Table 5 the percentage recaptures are compared for those tagging experiments where two or three different tags and methods of fastening were used simultaneously (number of herring tagged in brackets).

Table 5. Returns by Types of Tags and Methods of Fastening (%).

Comparisons at experiment nos.	6 & 8	6 & 11	6 & 12	8	9, 10 & 11
Lea tag.....	29(172)	23(227)	22(124)	—	—
Blue; twined nylon	27(175)	—	—	33(86)	—
Red; twined nylon.	—	20(56)	—	-	—
Red; untwined nylon.....	—	—	14(70)	—	—
Blue; soft nylon..	—	—	—	28(85)	20(234)
Red; soft nylon ..	—	11(73)	—	—	25(124)

In some comparisons the number of fish tagged is rather small, but it is seen that the superiority of the Lea tag over the blue tags fastened with twined stiff nylon is not always conspicuous; also the red tags fastened with twined, stiff nylon may compete with the Lea tags.

On the other hand the untwined, stiff nylon may seem to be less adequate than the Lea tag. The braided, soft nylon may seem to be less adequate than the twined, stiff nylon; especially the suitability of the tags fastened with the soft nylon as compared with other methods of fastening should be tried further.

From Table 4 it seems that the blue tags generally are superior to the red ones, but from Table 5 it appears that this result is not quite certain, and this must also be considered in further experiments.

Some Results of the Tagging.

1. The percentage of recaptures was surprisingly high for the tagging experiments in the inner Danish waters. Most recaptures, 33 % of the plastic tags and 46 % of the Lea tags were returned in a tagging experiment at Hvalpsund in the central Limfjord and in an experiment off North-Seeland near the entrance to the Isefjord 31 % of the plastic tags and 40 % of the Lea tags were returned.

In an experiment south of Als about 30 % of the Lea tags and about 25 % of the blue plastic tags were returned and in each of the experiments 5, 6, 11 and 12 about 20 %. Only the four first experiments, where long transports by rough sea may have influenced the rate of mortality, gave rather small recaptures.

The annual percentages of recaptures are less than the total annual reduction of the stock by the fishery. Some tags are shed by the fish before capture or are lost in the gear without being seen, and some few have not been returned by the finder. On the other hand, the result may be affected, if the herring are tagged at the beginning of the fishing season or when it is nearly finished. In the first case there is a short time only for shedding the tags before the fish are exposed to fishing and the percentage of recapture must be much nearer the real percentage of reduction of the stock than in the last case. When the herring goes almost a year under much less intense fishing proportionately many tags are shed or lost by natural mortality before the next season of intense fishing. The above mentioned experiment in the Limfjord was carried out at a spawning place in about the middle of the local fishing season and most of the others near the end of the local fishing season. Therefore the annual reduction of these stocks of herring by the fishery are even greater than indicated by the percentages of recaptures.

Thus the annual fishing mortality for the herring in the Limfjord is well above 50 % but the same annual toll seems to be taken by the fishery in the Belts and the western Baltic.

2. The mature herring found near the Scaw in the spring migrate south along the east and west coast of Jutland to spawning places partly off the Kattegat coast of Jutland south of the entrance to the Limfjord, and partly in the Limfjord and Nissum fjord. From the Limfjord they go back to the Skagerak after spawning. The spring spawners of the Belt Sea may spread over this area and over the Kattegat after spawning.

The important spawning place at Rügen is sought *inter alia* by herring which may be found in considerable quantities and sometimes almost unmixed off Copenhagen, and some herring arrive at this spawning place from the Belt Sea and from the southern Kattegat. This spreading of the Baltic spring herring over large parts of the Transition Area is an unexpected result of the tagging experiments.

Young of the North Sea herring constitute a small part of the herring in the Belt Sea. This was to be expected because we know from racial investigations that they mostly constitute the major part of the immature herring in the Skagerak, and naturally from here they may stray into the Belt Sea.

3. The migration may be comparatively fast and long just before spawning. For example, some of the mature herring tagged at Skagen were recaptured a fortnight later in the Limfjord. The fact, known from previous investigations, that mature herring in most cases will swim against the current has been confirmed.

Also, herring which are not mature may perform fast migrations, but in some of these cases they have obviously been transported by the current.

8.

The Movement of Herring in British Columbia Waters as Determined by Tagging.

With a Description of Tagging and Tag Recovery Methods.

By J. C. Stevenson

Summary.

The tagging and tag recovery programme on British Columbia herring was undertaken primarily to determine the degree of discreteness of herring populations and to delineate the region of inshore concentration of each.

From 1936 to 1951, the number of herring tagged amounted to 555,521 comprising 310 individual taggings. All the fish in each individual tagging were tagged at the same place and at the same time, the object being to have each such tagging consist of fish from a single school.

Taggings were carried out on all main herring stocks in British Columbia waters, but certain stocks were tagged more consistently and more intensively than others. In the early years of the investigation a general coastwise tagging programme was undertaken, but in later years intensive tagging was carried out on the major herring stocks, one after another.

Tagging was undertaken in three main periods of the year: (1) in late winter and early spring after the fishery was over and when the fish were in spawning condition, (2) in the early autumn (in the Strait of Juan de Fuca) at which time fish were moving inshore, and (3) during the period of the fishery. Most of the individual taggings (89 %) took place on spawning or spent fish. Recovery from these taggings was particularly useful in determining extent of intermingling of stocks since at least six months elapsed between tagging and recovery; recovery was not possible until the herring returned to inshore waters from summer offshore feeding grounds and were subjected to the regular autumn and winter fishery.

The tagging procedure involved catching and impounding the herring, making a small incision in the body wall of each fish, and inserting a nickel-plated iron tag through the incision into the body cavity. In the course of the investigation numerous variations in procedure occurred with regard to type of impoundment, length of time the fish were impounded before tagging, method of making the incision, and type of tag used. Differences in recovery arising from these changes in procedure were not statistically significant. It was found, however, that overcrowding of fish in the impoundments prior to tagging led to reduced recovery of the tagged fish.

Results of experiments suggested that tagging mortality was at least 60 %. These experiments showed that great care was required in handling the fish prior to tagging and in inserting the tags.

Differences were found in tag recovery from taggings carried out by experienced and by inexperienced taggers, but such differences were seldom significant.

Two types of equipment were used in the processing plants to recover tags: electronic tag detectors and magnets. The essential features of detector recovery were an electrically-energized coil placed in a conveyer chute of the plant, which detected the passage of a tag in the chute, and a trap-door system located a few feet further down the chute, which automatically by-passed the tagged fish. The tag detectors were of two types: the bridge type, in which the presence of a tag created an impulse by upsetting the electrical balance of four coils in Wheatstone bridge formation, and the induction type, in which a tag created an impulse by inducing a current in a secondary coil which was connected to a coil with a primary winding. Two models of each type of detector were operated.

The second method of recovering tags involved the installation of electro-magnets and permanent magnets in the meal-line of herring reduction plants. Tags passing over the magnets with the herring meal were held and later picked off the magnets by plant employees. Tags were also obtained from cracks and crevices of plant machinery, and these tags together with those from magnets were referred to as plant recoveries. A reward of 50 cents a tag was paid to plant employees for returning the tags to herring investigators with pertinent information on date and place of capture.

The chief problems in detector recovery were the maintenance of high sensitivity in the field of the detector coil and the proper timing of the opening of the trap-door to ensure recovery of tags detected by the coil. The basic difficulty in maintaining high sensitivity to the presence of tags stemmed from the fact that the impulse created by a tag was never greater (and generally less) than twice the general level of inherent interference within the detection circuit. Outside interference, arising from several

sources, sometimes created impulses in the detection circuit which exceeded that produced by tags, resulting in low detector efficiency. Various methods were employed to reduce the effect of outside interference, but they were only partially successful.

Because of the high cost of manufacturing, maintaining, and operating tag detectors, it was possible to install detectors in relatively few processing plants. On the other hand, magnets were installed in all plants at relatively low cost. Over six times as many tags were recovered by magnets and plant machinery as by detectors.

Plant recoveries were less useful in studying herring movements than detector recoveries because some doubt usually existed with regard to the exact fishing locality from which each plant recovery was taken. This uncertainty arose from the fact that a variable period of time elapsed between the unloading of a tagged fish at a plant and the passage of the tag over the magnet. Thus, while knowledge of where a particular load of fish was caught readily identified the area of capture of detector recoveries, this knowledge was frequently insufficient to give positive identification of the locality of capture of tags taken from magnets or plant machinery. The extent of the time lag in various plants was investigated, and this information was sometimes helpful in interpreting the area of recovery of plant returns. The efficiency of plants in recovering tags from the catches was generally greater than the efficiency of detectors.

The general method of studying the intermingling of herring stocks necessitated relating the actual numbers of tag recoveries to the estimated total number of tags in the catches. Certain assumptions were involved in this method of analysis. They pertained to rate of exploitation, recruitment, intensity of tagging, and random distribution of tagged fish in the stocks.

The total number of tags recovered in the fishing seasons from 1936—37 to 1951—52 was 20,328, or 3.7 % of the number of fish tagged. The percentage recovery was considerably greater in the later years of the study than in the early years, due mainly to increased opportunity for plant recovery and generally increased exploitation of the herring stocks. All but 14 of the 310 individual taggings produced returns. Recovery of tags decreased with increase in time between tagging and recovery.

The recovery data revealed a strong tendency for tags to be recovered in or near the area of tagging, indicating that most herring return in the autumn and winter to the inshore area in which they spawned the previous spring. It was concluded that British Columbia herring comprise a limited number of more or less distinct populations, a conclusion which is in general agreement with results from studies on meristic characters, age composition, and growth.

Migratory and resident herring populations were distinguished on the basis of population abundance, seasonal migration, growth and age composition, location of spawning grounds, and homogeneity of individual runs. Eight migratory populations were identified according to the general coastal regions in which they spawn and are fished: (1) the east coast of the Queen Charlotte Islands, (2) northern mainland coast, (3) north central mainland coast, (4) south central mainland coast, (5) middle east coast of Vancouver Island, (6) lower east coast of Vancouver Island, (7) south-west coast of Vancouver Island, and (8) north-west coast of Vancouver Island. There is a tendency for the main fishing and spawning grounds of each population to be located in the more southerly part of the region (or sub-district) of their inshore concentration, and for movement within each sub-district to be northerly. This has suggested that the route of migration from offshore feeding grounds to inshore waters is also northerly, and this indication is supported by the only tag recovery taken from offshore waters. The migratory populations provide about 95 % of the annual herring catch.

The numerous small resident populations are mostly concentrated in the long inlets of the north central, south central and upper east coast regions. Information on their movements is sparse since not all have been tagged. They show a considerable degree of isolation from neighbouring migratory populations and from each other. Herring of resident populations are relatively slow-growing, suggesting that their summer feeding areas are less productive than the offshore feeding areas of the migratory stocks.

The recovery data indicated that about one-quarter of the fish of each major migratory population emigrates to other populations. Fish of the middle east coast of Vancouver Island showed the greatest emigration (45 %), an indication that this population was the least independent stock. Least emigration occurred from the lower east coast population (16 %).

The amount of emigration from one population to another varied with the distance separating the populations. It was concluded that the herring of British Columbia tend to form a series of intergrading populations.

The individual herring runs of the south-west coast and north-west coast of Vancouver Island showed a type of intergradation which resembled, on a smaller scale, the intergradation of the major migratory populations. There was evidence that the individual runs within the northern and north central populations also followed this pattern. In contrast, the runs within the population of the lower east coast of Vancouver Island appeared to be freely mixing and homogeneous showing no differential emigration outside the sub-district.

Emigration from individual herring runs of the middle east coast resembled that of the runs of the west coast populations in certain respects. However, the presence within this sub-district of resident or partially resident stocks, as well as a migratory stock, resulted in a relatively complicated situation.

9.

Review of Scottish Herring Tagging Experiments, 1948—1953.

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PART I.

Description of Tagging Methods.

Introduction.

So far as is known, scientists of the Fishery Board for Scotland made the first efforts at marking and tagging herring (Fulton, 1893). The first method was to punch a triangular hole in the tail fin but this experiment was unproductive and later a metal tag consisting of a barbed hook carrying a rigid numbered plate on the shaft was used, unfortunately also without success.

American scientists in 1927 experimented with external tags on Pacific herring without, however, achieving conspicuous success (Rounsefell, 1930). They finally made the bold experiment of inserting a small numbered metal plate into the body cavity, which could be recovered magnetically during processing. This innovation has proved most successful both in North America and, since the war, in Norway and Iceland, where the bulk of the fish is converted into meal and oil.

Preliminary Experiments 1948—1950.

When herring tagging experiments were again undertaken in Scotland in July 1948, most of the North Sea catch was prepared and sold for human consumption so that it was necessary to use an external tag which had a chance of being seen by fishermen or others engaged in the industry. The tags first used consisted of a strip of pliable green plastic, tapering at both ends and about 8 to 10 mm. wide at the widest part, as shown in Figure 1. The tag was applied round the body of the fish immediately behind the pectoral fins and was secured by a small fastener of stainless steel, which bore a serial number. The herring used in these experiments were caught by drift-net from the Scottish research vessel "Clupea". In 1948, 892 herring were tagged and one fish was recovered, and in 1949 out of a total of 1,124 fish tagged 4 were recaptured.

The application of this band tag was a slow and

Figure 1.

chilling process and by the end of 1950 experiments had been made with three other types of tags. They were as follows:—

1. Numbered rubber band (fixed immediately behind the pectoral fins).
2. Lea's hydrostatic tag (attached in front of the dorsal fin by means of a bridle of steel wire).
3. Plastic strip (Danish "flag" tag), attached by wire through the dorsal musculature in front of the dorsal fin.

All of the liberations with these tag types in the period 1948—1950 were made on the Scottish north-east coast and Shetland fishing grounds from drift-net catches taken by F.R.S. "Clupea". A small fleet of 17 nets was used. As the nets were hauled on board the herring were shaken from the meshes into boxes full of sea water, from which they were transferred at short intervals to a storage tank with an abundant water supply. Only the liveliest, undamaged herring were selected for tagging. The tagging operation was completed under water and the fish were returned immediately to the sea.

A total of about 7,000 herring was liberated in this manner in the three years, and 23 recaptures were recorded. Each of the tags used was represented in the returns, but the number of recaptures was too small to make possible a satisfactory assessment of the merits of each type.

The most important result which emerged from these experiments was that reasonably long-period recaptures could be obtained from herring caught by drift-net. It was evident, however, that, in order to increase the numbers of recaptures without increasing the scale and cost of the investigation greatly, it was necessary to devise a tagging technique which would provide a much larger number of liberations during the course of the fishing season.

It was evident that tagging mortality was only one of a number of important factors which resulted in the loss of recapture data; others such as tag-shedding, tags unobserved in the catches, etc. were mostly independent of the condition of the fish at liberation.

In these circumstances it was decided to investigate the possibility of conducting large-scale tagging experiments from *commercial* drift-net vessels. A preliminary experiment made by Mr. G. Bolster on board a commercial drifter in 1950 had indicated the possibilities of success by this method. It was considered that if liberations could be increased four or fivefold with the same effort in scientific manpower, substantially greater numbers of recaptures might be obtained even if tagging mortality was increased as a result of less careful handling.

The first step in developing a method of tagging from commercial drifters was to devise a tag and a tagging technique which allowed the work to be carried out on the deck of the vessel without interfering seriously with the fishing operations. The technique had to be as simple as possible, and the number of operators on each vessel as small as possible, preferably one man.

Two fundamentally different methods of herring tagging, "internal" and "external" were possible, each appropriate to particular practical circumstances. Internal tagging is the most appropriate when the herring are bulk handled in reduction plants, and the possibilities of spotting the tags in the catch are very small; external tagging is most appropriate when the fish are handled singly or in small quantities and where there is no easy method of recovering the tags mechanically. Norwegian workers have shown recently that both methods can be used together on the same fish. The choice of method is governed largely by the type of fisheries practised in and adjacent to the centres of tagging.

In the North Sea, the fisheries for adult herring are conducted mainly by trawl and drift-net by a number of countries and the catch is treated in a variety of ways. Large quantities are bulk handled in reduction plants and the remainder are processed in one way or another for human consumption. It would appear, therefore, that the most appropriate tagging technique for the North Sea herring investigations was one incorporating both "internal" and "external" methods. In the absence, however, of magnetic separators in many of the reduction plants in European countries, it was decided to continue to concentrate the Scottish effort on "external" tagging, and to rely for recaptures mostly on the fish which were treated for human consumption. So far as could be judged from the rather scanty information as to the disposal of the adult herring catches in the North Sea, this would not introduce any serious bias in the biological results which accrued.[1])

The Development of a "One-Man" Tag.

Attention was first given to developing a simple method of attachment which could be manipulated by a single operator. After several trials a form of "toggle" attachment shown in Figure 2 A was adopted and this has been used in almost all the experiments conducted since 1950. Recently, however, experiments have been made with a new form of "bridle" attachment illustrated in Figure 2 B. The "toggle" attachment consists of a wire "anchor" which is attached to the tag by a loop of nylon thread. A cheap and effective "toggle" was made by twisting two strands of nickel or stainless steel wire tightly together and incorporating the ends of a nylon loop during the twisting process. A simple apparatus, designed by Mr. G. Davies, can turn out toggles at the rate of about 100 per hour. They are made in strings and are then cut up into single toggles of any required length. (See Figure 3.)

The development of a suitable tag was conditioned by the following requirements: (a) availability in large numbers, (b) cheapness, (c) certain hydrostatic properties, and (d) conspicuousness on capture. The tag adopted is illustrated attached to the fish in Figure 2 C. It consists of two "boat-shaped" sections of a plastic "polystyrene" (Figure 2 A), cemented together and containing a numbered strip of paper which can be read through the material of the tag. On one side are impressed the words "Reward Marine Laboratory Aberdeen". The specific gravity of the tag without a metal strip is approximately 0.81; when a metal strip is incorporated in the tag the specific

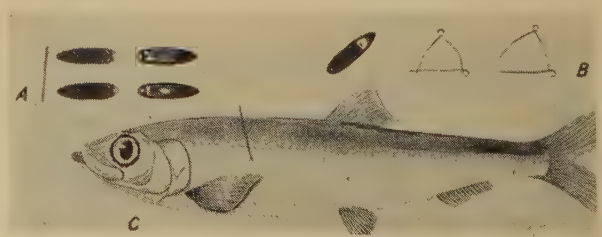


Figure 2.

[1]) Experiments were conducted in 1951 and 1952 on the possibilities of extracting the external tags from reduction plants, by incorporating a small numbered plate of thin steel (0·5″ by 0·1″) in the body of the tag. The results of these experiments showed that while the metal strips were recovered when they were distributed free amongst the mass of herring fed to the plant the tags containing the strips were not recovered. This was probably due to the magnetic attraction being insufficient to draw the relatively bulky tag through the damp mass of partially processed material. Its use was therefore discontinued in subsequent tagging experiments.

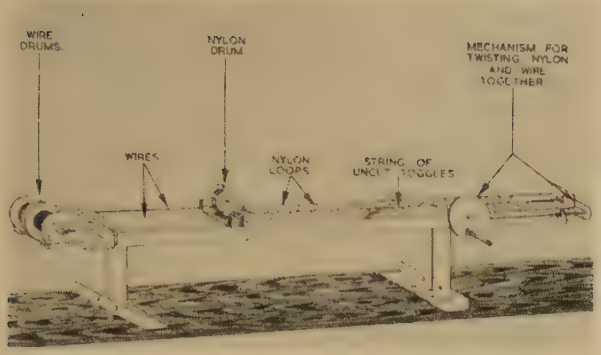


Figure 3.

gravity is 1.05 which ensures positive buoyancy in average sea water. The sections of the tag are mass-produced and they are made up into the complete tags in the laboratory. The cost for each complete tag is approximately 6d.

The toggle attachment has also been used in some Scottish experiments with the Lea hydrostatic and the Danish flag type tags.

The Method of Tagging.

Early trials showed that the whole tagging operation with the toggle attachment could be quickly completed by a single operator; furthermore, it was soon found that with some experience it was possible to dispense with water containers for testing the liveliness of the herring before and after tagging.

The technique which had been adopted in the experiments since 1950 is as follows:—the operator selects the liveliest herring as they drop from the nets on to the deck of the vessel, tags them quickly in air, and then immediately returns them to the sea. A supply of tags is kept ready in bandoliers, each holding from 50 to 60 tags, which are worn round the waist.

Experience has shown that the best method of handling is to hold the fish firmly in the cup of one hand, with the head pointing forward, and to insert the toggle in the mid-dorsal line and press it forwards and sideways through the flesh of the back so that it emerges in front of and to the side of the point of entry.

Tagging Rate.

The number of herring which an operator can tag effectively with the one-man tag in the course of a single drift-net haul will be determined by a number of factors. Chief amongst these are:—(a) the availability of live herring, (b) the care taken in the selection of the fish for tagging, (c) the weather conditions, cold, state of sea, etc., and (d) the skill of the operator.

A number of experiments have been performed to determine the maximum rate of tagging which an operator of average experience can attain under good conditions, i. e., a constant supply of live, undamaged fish and a calm sea. The tagged herring were placed in a tank on board ship and were kept there under observation for an hour before being liberated. The numbers of herring which failed to swim away after being liberated were also noted. The results of these trials are given in Table 1.

Table 1.

Experiment	Number of herring tagged	Total time (mins.)	Average time per tagging (secs.)	Number of herring dying within 1 hr. of tagging	Number of herring failing to swim away on liberation
1.....	60	25	25·0	0	0
2.....	43	21	29·3	0	0
3.....	66	30	27·2	0	0
4.....	75	32	25·5	0	0
Total.....	244	108	26·5	0	0

These results indicate that, given a continous supply of live herring and favourable weather conditions, an operator could tag between 400 and 600 herring during a drift-net haul of 3 to 4 hours' duration and confirms that the numbers of *immediate* deaths resulting from the handling technique is negligible.

Conditions in the open sea drift-net fisheries rarely permit this tagging rate to be attained. In some hauls most of the fish are dead when they are brought aboard, and in others they are too tightly meshed to be taken from the net in a completely undamaged state. The average rates actually accomplished in the North Sea during the 1951—53 tagging experiments are presented in Table 2.

Table 2.

Tagging area	Year	Total No. of liberations	Number of hauls (one operator per haul)	Average No. of liberations per operator per haul
Scottish north-east coast	1951	5714	55	105
	1952	8214	52	158
	1953	6811	35	195
	Total...	20739	142	146
Shetland	1951	1867	22	85
	1952	2979	18	166
	1953	998	15	67
	Total...	5844	55	106

While on one occasion in 1953, 1,000 herrings were tagged by a single operator during the course of a single commercial drift-net haul, the figures in Table 2, which are based on all the hauls for which tagging experiments had been planned including those from which no live herring were available, show that a single operator on a commercial vessel using the Scottish tag with toggle attachment can be expected under average conditions to tag from 600 to 800 herring in a normal fishing week comprising 5 hauls. In fact with the introduction of the toggle attachment tagging costs have been reduced and the tagging rate has been increased fourfold that obtained from the other types of tag used in the Scottish experiments,

and by making use of commercial vessels the choice of tagging centres has been made much more flexible while the research vessel has been left free to undertake other work.

Observations of tagged fish in captivity. In the preliminary trials with the new technique only short-term observations could be made on the fish after tagging and, as shown in Table 1, these indicated that mortality due to the handling technique was negligible up to one hour after the attachment of the tag. Nothing, however, was known of the magnitude of the mortality due to tagging, or the incidence of tag shedding. The magnitude of these sources of tag loss relative to other methods of tagging had in fact to be judged from the recapture data.

In October 1953, however, a small number of tagged and untagged herring were successfully established in aquarium tanks at the laboratory, and these have provided longer term data on the relative mortalities of tagged and untagged fish, the incidence of tag shedding, the history of the wound made during the attachment of the tag, and the general behaviour of the tagged fish.

Ten herring between 18—20 cm. in length, tagged in the normal way with the Scottish tag and toggle attachment and 10 untagged herring of the same size range from a beach-seine catch were placed in the aquarium tank on 26. October. Food was offered to the fish daily. After a period of about 12 days, during which neither the tagged nor untagged herring took food, regular feeding commenced by members of both groups and up to the time of writing no differences in their feeding habits and general behaviour have been observed.

Up to 15. May 1954, 200 days after introduction into the tank, 2 tagged and 1 untagged herring have died. In addition 3 tagged herring have shed their tags. In one instance the tag became detached from the toggle due to a faulty attachment, but in the remainder the tag with toggle attached was shed as a result of the nylon cutting through the flesh. The two tagged fish deaths took place 1 day and 10 days, respectively, after tagging and the tags were shed after 72, 95 and 118 days, respectively. The untagged fish died 10 days after introduction into the tank.

These results suggest that long-term mortality due to the effect of the tag is probably not a serious cause of tag loss, but that tag-shedding may be, and it would appear that the loss becomes significant after periods of three to four months by the gradual increase in size of the tagging wound by the movement of the nylon thread. Observations taken at intervals after tagging have shown that the increase in size of the wound varies according to the angle of the nylon at the point of emergence from the back of the fish. The increase has been least in those instances where the nylon runs approximately anteroposteriorly, as in Figure 4 A, and greatest when it makes a large angle with the longitudinal axis of the fish at the point of emergence, as in Figure 4 B. In all instances

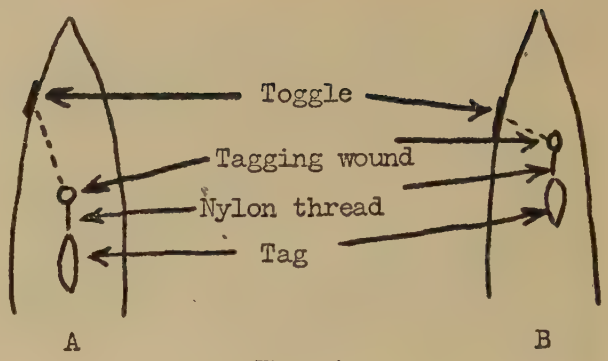


Figure 4.

the wound has remained open with no evidence of decay of the tissue.

In the light of these observations it is thought that tag-shedding has been a substantial source of long-term tag loss in the Scottish experiments since 1950. In support of this are 13 records of Scottish tags found stranded along the coasts of western Europe, all at intervals exceeding two months from the time of liberation.

As mentioned earlier, a new design of bridle has been designed recently, and experiments will be conducted in 1954 in the aquarium and at sea, to determine whether long-term tag-shedding can be reduced by its adoption.

During the course of experiments in the aquarium, a number of easily remedied defects of the complete tag assembly have been brought to light which may have contributed to tag-shedding in experiments to date. Hitherto, the toggle has been attached to the tag by looping the nylon thread through the eye in the tag, as in Figure 4 C; experiments have shown that this form of attachment can come undone when long nylon loops are used as in Figure 4 D. The loss of the tag after 72 days was from this cause. This defect has been remedied by using a double loop at the point of attachment of the tag. It has also been found that the application of adhesive to the twisted wire of the toggle to prevent the nylon from slipping results, after long immersion in the sea, in a gradual decay and eventual breakage of the nylon at the point where it joins the wire.

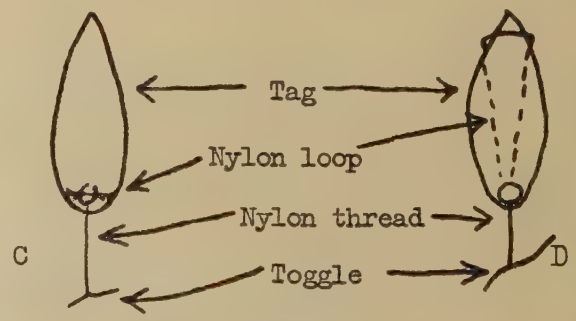


Figure 4.

Table 3. Recaptures from Experiments on Commercial Vessels in 1951.

Area of liberation	Type of tag		Month of liberation May	June	July	Aug.	Sept.	Total
Scottish north-east coast	Lea hydrostatic	No. liberated	1440	—	—	—	—	1440
		No. recaptured	51	—	—	—	—	51
		% recaptured	3·54	—	—	—	—	3·54
		Days at liberty	1—263	—	—	—	—	1—263
	Scottish hydrostatic	No. liberated	—	1293	1827	494	150	3764
		No. recaptured	—	26	18	1	1	46
		% recaptured	—	2·01	0·99	0·20	0·67	1·22
		Days at liberty	—	0—100[1])	1—70	[1])	[1])	0—100
	Flag	No. liberated	—	410	—	—	—	410
		No. recaptured	—	10	—	—	—	10
		% recaptured	—	2·44	—	—	—	2·44
		Days at liberty	—	10—140	—	—	—	10—140
Shetland-Orkney	Scottish hydrostatic	No. liberated	—	1247	720	—	—	1967
		No. recaptured	—	12	6	—	—	18
		% recaptured	—	0·96	0·83	—	—	0·92
		Days at liberty	—	21—238	13—48	—	—	13—238
North Minch	Scottish hydrostatic	No. liberated	—	299	200	—	—	499
		No. recaptured	—	2	—	—	—	2
		% recaptured	—	0·67	—	—	—	0·40
		Days at liberty	—	1—53	—	—	—	1—53
All liberations in 1951		No. liberated	1440	3249	2747	494	150	8080
		No. recaptured	51	50	24	1	1	127
		% recaptured	3·54	1·54	0·87	0·20	0·67	1·57
		Days at liberty	1—263	0—238[1])	1—70	[1])	[1])	0—263
All liberations in 1949 and 1950		No. liberated	2335	1966	1406	329	—	6036
		No. recaptured	7	10	3	2	—	22
		% recaptured	0·30	0·51	0·21	0·61		0·36
		Days at liberty	75—257	4—92	3—68	1—2	—	1—257

[1]) 2 fish liberated off Scottish NE. coast in June and 1 in August and September, respectively, recaptured on night of liberation near tagging area.

Recaptures from "One-Man" Tagging Experiments and Comparisons of Tag Types 1951.

The first experiment with the one-man tag was made in May 1951, and further experiments designed to study the migration of herring from the north-western North Sea were made at intervals between May and September on the north-east coast and Shetland drift-net grounds. Experiments were also made in the Minch in June, July and September.

Three types of tag were used in 1951, the Lea hydrostatic tag, the new Scottish tag and the plastic flag tag; all were used with the toggle attachment. The first deliveries of the Scottish tag were not made in time for the May experiment, when only Lea tags were used, but thereafter most of the liberations were made with the Scottish tag.

The recaptures reported to date from the 1951 liberations are given in Table 3, together with the percentage of each type of tag recaptured and the period of time after liberation within which the recaptures were made.[1])

The corresponding information for the research vessel experiments in the North Sea in 1949 and 1950 are also given.

The most important result from the 1951 experiments was the large increase in the number of recaptures over the two previous years. These were approximately five times greater than the combined recaptures from the 1949 and 1950 liberations; the percentage recaptured was also much greater. While the recovery of tags was promoted by a growing public interest in the experiments, it is not possible to ascertain whether the great increase in tag recoveries in 1951 was due primarily to the differences between the tags or tagging techniques employed in the two periods, since no comparable research vessel experiments were made during that year; the results, particularly from the North Sea experiments, indicated that the new technique was much more effective than the one hitherto in use.

Of the three types of tag used, Lea's tag gave the highest and the Scottish tag the lowest recapture percentage. It should be kept in mind, however, that on only one occasion, in June on the Scottish north-east coast grounds, were two or more of the types used together in the same experiment. The percentage recaptures from the Scottish and the flag tags on this occasion were not significantly different. While it was not possible to determine precisely from these experiments the relative merits of all the tag types, it was clear from the recaptures from the North Sea liberations in May and June that all three gave worthwhile results. Experiments designed to test the relative efficiencies of the two main types, the Lea and Scottish hydrostatic tags were subsequently conducted in 1952.

[1]) The returns repeated in this and all subsequent tables include only those which are known to have been recaptured during fishing operations.

Table 4. Recaptures from Commercial Experiments in 1952.

Area of liberation	Type of tag		Month of liberation: Feb.	April	May	June	July	Aug.	Total
Scottish north-east coast	Lea hydrostatic	No. liberated	—	—	330	331	133	—	794
		No. recaptured	—	—	10	24	5	—	39
		% recaptured	—	—	3·03	6·25	3·76	—	4·91
		Days at liberty	—	—	67—399	0—105	0—130	—	0—399[1]
	Scottish hydrostatic	No. liberated	—	—	1649	2756	1797	1218	7420
		No. recaptured	—	—	35	80	42	7	164
		% recaptured	—	—	2·12	2·90	2·34	0·57	2·21
		Days at liberty	—	—	36—161	1—397	1—95	0—25	0—397[2]
Shetland	Lea hydrostatic	No. liberated	—	—	45	258	115	100	518
		No. recaptured	—	—	2	6	1	2	11
		% recaptured	—	—	4·44	2·33	0·87	2·00	2·12
		Days at liberty	—	—	43—63	39—218	18	5—149	5—218
	Scottish hydrostatic	No. liberated	—	—	226	1287	749	199	2461
		No. recaptured	—	—	3	35	5	—	43
		% recaptured	—	—	1·33	2·72	0·67	—	1·75
		Days at liberty	—	—	35—77	2—148	6—50	—	2—148
North-eastern North Sea	Scottish hydrostatic	No. liberated	—	1308	—	—	—	—	1308
		No. recaptured	—	6	—	—	—	—	6
		% recaptured	—	0·46	—	—	—	—	0·46
		Days at liberty	—	40—134	—	—	—	—	40—134
North and South Minch	Lea hydrostatic	No. liberated	200	—	—	—	175	249	624
		No. recaptured	2	—	—	—	2	1	5
		% recaptured	1·00	—	—	—	1·14	0·40	0·80
		Days at liberty	1—44	—	—	—	?—416	0	0—416[3]
	Scottish hydrostatic	No. liberated	689	200	—	156	468	1747	3260
		No. recaptured	3	—	—	2	3	11	19
		% recaptured	0·44	—	—	1·28	0·64	0·63	0·58
		Days at liberty	4—27	—	—	47	48—195	22—181	4—195
All open sea "commercial" liberations in 1952		No. liberated	889	1508	2250	4788	3437	3513	16385
		No. recaptured	5	6	50	147	58	21	287
		% recaptured	0·56	0·40	2·22	3·07	1·69	0·60	1·75
		Days at liberty	1—44	40—206	35—399	0—397	0—416	0—181	0—416

[1]) 1 herring in June and 1 in July recaptured on night of liberation near the tagging area.
[2]) 2 herring in August recaptured on night of liberation near the tagging area.
[3]) Recapture in August made on night of liberation near the tagging area.

Experiments in 1952.

The one-man tagging technique, which had given such encouraging results in 1951, was again employed in 1952 on a more extensive scale. Once more, the main objective was to study the migrations of herring from the summer drift-net grounds in the North Sea, and tagging was carried out in this area from commercial vessels in each of the months from May to August. A small number of liberations was also made in this area by F.R.S. "Clupea" in April and May. The tagging effort on the west coast grounds was also increased, and in April tagging was undertaken for the first time in the north-eastern North Sea in the vicinity of the Coral Bank.

A small-scale experiment was also conducted on the "halflin" stock in the upper reaches of the Firth of Forth in January and March 1952 in order to trace the subsequent movements of these herring (in their 3rd year) from the nursery area to the open sea grounds. A total of 529 liberations was made resulting in 20 recaptures (3.78 %), all of which came from the vicinity of the tagging area.

In addition to these operations experiments were also made in 1952 to determine (a) the relative merits of the new Scottish technique and the much more meticulous technique used by Swedish workers in the Bohuslän area; (b) the relative efficiencies of different types and colours of tags when used with the Scottish toggle attachment. The first of these comparisons was made possible by the kind invitation to one of the authors by Dr. Höglund of the Swedish Fishery Board to take part in the spring tagging experiments along the Bohuslän coast. The second set of experiments was conducted during the course of the main summer tagging experiments in the North Sea, when two different types of tag and a number of different colour versions of the Scottish tag were used.

The total (and percentage) recaptures from all the open sea experiments made in 1952, except those resulting from the "Clupea" experiments and those from the Bohuslän coast experiment, are given in Table 4.

The number of liberations in 1952 and the number of recaptures were both more than twice as large as in 1951; percentage recaptures were also larger, particularly for the main North Sea summer experiments from which all but 30 of the recaptures were obtained.

Again, as in 1951, there were marked differences

between the percentage recaptures from liberations made in different areas and months. Recoveries from the North Sea summer liberations were once more very much greater relatively than from the west coast experiments. The results from the north-western North Sea experiments showed the same general time intervals between liberation and recapture as in 1951. Recaptures from liberations made in August were again relatively very much fewer than from the experiments made earlier in the season.

Table 4 shows also an overall difference in recoveries of the two main types of tag used in the experiments. When the Lea tag, which was equipped with the toggle attachment in all experiments, was used in the same series of experiments as the Scottish tag it gave a higher percentage recovery; this was especially true off NE. Scotland, where the percentage recovery of Lea tags was more than double that of the Scottish tag.

The number of liberations, however, with each type of tag differed each month, and Lea tags were not used at all tagging stations. It is probable, therefore, that a truer assessment of the relative merits of the two types is obtained from the results of the comparative experiments when the two types of tag were used on the same night.

Comparison between Tag Types and Colours.

Experiments in which Lea and Scottish tags were used in approximately equal numbers on herring tagged from the same haul, were undertaken on commercial vessels in the north-western North Sea in May and June, when a total of 5,173 herring were liberated. In these experiments a number of different colours of Scottish tag were used. In 1951, when the Scottish tag was first produced, only red tags were used, but in 1952 tags of different colours were employed. The colour types were: red, bright yellow, dull yellow (amber), one section red, one section bright yellow, one section blue, one section bright yellow. On all occasions the tags were used with the toggle attachment.

To ensure a random distribution of tag types amongst the herring liberated from each haul, the various tag types were distributed at random in the bandoliers worn by the operators.

The data from these experiments are summarized in Table 5, which gives the numbers of recaptures of each tag and colour type at successive time intervals after liberation.

Statistical analysis of the complete data shows no significant difference between the percentage recaptures of the Lea tag and the Scottish tags with a bright yellow component, but both of these give significantly higher values than the average for the other colour types of the Scottish tags. Thus it would appear that colour plays a large part in determining the relative efficiencies of two basically similar designs such as the Lea and Scottish tags. No important differences are shown between the recovery times for the two tag types; the number of recoveries of both types, which had been at liberty for more than six months, is too small for reliable conclusions to be drawn regarding their relative "long-term" merits. It is probable, however, that the provision in the Lea tag of detailed instructions to the finder in more than one language makes it more efficient than the Scottish tag when used in regions fished by a number of different countries.

While it is not possible to say to what extent the differences in efficiency of the colour types is attributable to differences in conspicuousness to predator species or in conspicuousness amongst the mass of fish after recapture, it is thought that conspicuousness on recapture is perhaps the more important factor. This is borne out by the marked difference in recapture percentage between the bright yellow and amber tags. The absorption spectra of these colours are very similar, but experiments on board ship have shown the bright yellow tag to be the much more conspicuous amongst a mass of herring.

Further data of the relative efficiencies of different tag types and colours are available from the experiments made off the Swedish coast in April 1952. The same colour types of the Scottish tag were used as in the North Sea experiments, and these and Lea

Table 5.

	Lea tag		Scottish tag												Total all tags	
			Red		Dull yellow (amber)		Bright yellow		Red/Bright yellow		Blue/Bright yellow		Total			
Number tagged	863		864		862		861		861		862		4310		5173	
Number recaptured	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Within 30 days	2	0·23	3	0·35	3	0·35	4	0·46	3	0·35	4	0·46	17	0·39	19	0·37
Between 31— 61 days	10	1·16	5	0·58	5	0·58	12	1·39	12	1·39	8	0·93	42	0·97	52	1·01
– 62— 91 –	11	1·27	9	1·04	2	0·23	7	0·81	9	1·04	8	0·93	35	0·81	46	0·89
– 92—183 –	6	0·70	5	0·58	2	0·23	2	0·23	3	0·35	2	0·23	14	0·32	20	0·39
– 184—365 –	1	0·12	—	—	—	—	—	—	1	0·12	—	—	1	0·02	2	0·02
After 365 days	1	0·12	—	—	1	0·12	—	—	—	—	—	—	1	0·02	2	0·02
Unknown	3	0·35	2	0·23	2	0·23	3	0·35	7	0·81	2	0·23	16	0·37	19	0·37
Totals	34	3·94	24	2·78	15	1·74	28	3·25	35	4·07	24	2·78	126	2·92	160	3·09
			2·26 %				3·37 %									

Table 6.

Tag type	Colour	Number tagged	Number recaptured	% recaptured	
Lea	Blue and bright yellow	57	—	—	
Scottish	Red	56	3	5·36	5·31
	Dull yellow (amber)	57	3	5·26	
	Bright yellow	57	6	10·53	12·28
	Red/bright yellow.	57	11	19·30	
	Blue/bright yellow.	57	4	7·00	
Total all Scottish		284	27	9·50	
Total all types		341	27	7·92	

tags were distributed in equal numbers amongst the fish tagged. The results from these liberations are contained in Table 6.

Apart from the absence of returns of the Lea tag, these results show the same general features as those from the North Sea experiments. Tags with a bright yellow component provided the greatest numbers of recaptures for the various colour types of the Scottish tag, and the red-yellow combination again gave the highest number of any one type. The practical significance of the greater efficiency of the red-yellow combination is obscure. The absence of recaptures of the Lea tag is very surprising since this tag is the one used in the Swedish experiments and is familiar to the fishermen operating in the Skagerak, where all recaptures from these experiments were obtained.

Comparison of tagging methods. The Swedish experiments also provided information on the relative merits of the Scottish method of tagging and the Swedish technique used by Dr. H. HÖGLUND. Approximately equal numbers of herring caught by pound-net were tagged on each of several days by each method and the two batches of herring were liberated together.[1])

Unfortunately, the quantities of herring caught during the course of the experiment were very small, and the number of comparable liberations made by the Swedish and Scottish methods was restricted to 237 and 238 respectively.[2])

The herring tagged by each method were placed in the same water container, and were liberated together. Observations taken at the time of the experiment showed no differences in the liveliness of the herring tagged by the two methods, and gave no indication of a difference in short-term tagging mortality between the two methods.

The numbers (and percentages) of recaptures from the two sets of liberations are presented in Table 7.

[1]) The reader is referred to Dr. HÖGLUND's contribution for details of the tagging technique employed in the Swedish experiments, and for a more detailed analysis of the recapture data.

[2]) The difference between the total for Scottish liberations given here and those stated in Table 6 is due to additional liberations, contained in Table 6 but not in Table 7, which were made after the comparative experiments had ceased.

Table 7.

	No. recaptured		Percentage	
	Swedish	Scottish	Swedish	Scottish
After 1 month	13	5	5·5	2·1 (2·2)[1])
– 3 months	21	12	8·9	5·1 (5·4)
– 6 –	27	17	11·4	7·1 (7·6)
– 8 –	33	18	13·9	7·6 (8·1)
– 12 –	42	18	17·7	7·6 (8·1)

[1]) Figures in brackets are percentages recaptured of Scottish tags, excluding the Lea tag.

These results show a higher recapture percentage of Swedish tags than of Scottish tags for all periods at liberty, but in particular they indicate a much more rapid fall-off in the numbers of recaptures of Scottish tags after three months. Whereas returns of the Swedish tag continued to be made one year after the experiments, no recaptures of Scottish tags have been reported after six months. These results are of particular interest in the light of those obtained subsequently with the herring kept in the aquarium, and point to a relatively high incidence of shedding of the Scottish tag. It is considered, therefore, that the difference in numbers of recaptures from the two sets of liberations are due mainly to differences in efficiency of the methods of attachment used rather than in the handling methods.

The results, however, must be viewed in the light of differences in the tagging rate with the two methods. On average, 4 herring were tagged with the Scottish method by a single operator during the time taken by a team of 3 scientists to tag 1 by the Swedish method. Thus, given a constant supply of herring a team of 3 operators would liberate much larger numbers by the Scottish than by the Swedish method, and at smaller cost. The greater tagging potential of the Scottish method more than compensates for the smaller recapture percentage at least up to six months after liberation.

One feature of the technique used in the Swedish experiments is the collection of length data and scale samples from all herring tagged. This has not been undertaken in the Scottish experiments; instead these data are only taken at the time of recapture. This inevitably results in a substantial loss of information since in many instances only the tags are received. Steps are being taken in the Scottish experiments to investigate the possibility of collecting scales at the time of liberation. It is clear, however, that the technique to be adopted will depend on the main objectives of the investigations, the resources available and on local fishing circumstances.

Experiments in 1953.

The open sea tagging experiments in 1953 followed the same general lines as in 1952. The "commercial" technique was employed throughout, and either Scottish or Lea tags were used with the toggle attachment. Small numbers of liberations were also made with

Table 8. **Recaptures from Commercial Experiments in 1953.**

Area of liberation	Type of Tag		Month of liberation April	May	June	July	Aug.	Total
Scottish north-east coast	Scottish hydrostatic	No. liberated	—	3995	1418	1229	169	6811
		No. recaptured	—	41	7	19	1	68
		% recaptured	—	1·03	0·49	1·55	0·59	1·00
		Days at liberty	—	0—157	1—203	1—202	16	0—203[1])
Shetland	Scottish hydrostatic	No. liberated	—	338	565	85	—	988
		No. recaptured	—	9	9	1	—	19
		% recaptured	—	2·66	1·59	1·18	—	1·92
		Days at liberty	—	59—252	1—70	16	—	1—252
North of Fladen (approx. 58°45′N. 1°00′E.)	Scottish hydrostatic	No. liberated	200	400	—	—	—	600
		No. recaptured	5	4	—	—	—	9
		% recaptured	2·50	1·00	—	—	—	1·50
		Days at liberty	143—179	83—136	—	—	—	83—179
North Minch	Lea hydrostatic	No. liberated	—	—	—	120	880	1000
		No. recaptured	—	—	—	0	2	2
		% recaptured	—	—	—	0	0·23	0·20
		Days at liberty	—	—	—	—	4—118	4—118
	Scottish hydrostatic	No. liberated	—	—	—	769	1389	2158
		No recaptured	—	—	—	2	5	7
		% recaptured	—	—	—	0·26	0·36	0·32
		Days at liberty				79—193	3—138	3—193
All liberations in 1953		No. liberated	200	4733	1983	2203	2438	11,557
		No. recaptured	5	54	16	22	8	105
		% recaptured	2·50	1·14	0·81	1·00	0·33	0·91
		Days at liberty	143—179	0—252	1—203	1—202	3—138	0—252

[1]) 1 herring in May recaptured on night of liberation in vincinity of the tagging area.

the one-man bridle shown in Figure 2 C. All Scottish tags used in 1953 possessed a yellow component.

The total numbers of liberations and recaptures to date, including those made with the bridle attachment, for each of the open sea experiments in 1953 are given in Table 8.

The percentages recaptured from the 1953 liberations were appreciably lower than in 1951 and 1952 except for the experiments in the north-eastern North Sea. The greatest drop in recoveries was from liberations made off the north-east coast of Scotland in May and June; while recoveries from the experiments in these months in 1952 averaged 2.8 %, those from the 1953 experiments averaged only 0.9 %. While further returns from those experiments may yet be received, it is unlikely that they will be in sufficient numbers to increase this percentage appreciably. The reason for this decrease in returns is not known, but it is believed that it may be, in part at least, the result of a general increase in 1953 in the proportion of the total European herring catch which was bulk handled in reduction plants. Alternatively, it is not possible to assess to what extent this drop in recoveries might be related to an overall decrease in effort and catch in 1953 since no effort statistics for the total European herring fisheries in the North Sea are available.

Features of the 1951 and 1952 recapture data which are repeated in the 1953 figures are:—

1) The much smaller recovery of tags from the Minch experiments than in the North Sea.

2) The smaller percentage recapture from liberations in the North Sea in August compared with the earlier months.

Table 9.

		Number liberated	Number recaptured	Percentage recaptured	Time at liberty (days)
Scottish north-east coast	Toggle ..	100	0	0	—
	Bridle...	199	5	2·51	1—203
Shetland	Toggle ..	60	0	0	—
	Bridle...	120	2	1·67	79—193
Upper Moray Firth	Toggle ..	130	2	—	[1])
	Bridle...	251	6	2·39	5—67

[1]) Both fish caught on night of liberation in tagging area.

Comparison between Toggle and Bridle Attachments.

Experiments in which the bridle and toggle attachments were used together were made on the north-east coast grounds in June, and on the Minch grounds in July. In addition, liberations with both types of attachment were made on the "halflin" fishing grounds in the upper reaches of the Moray Firth in December and again in March 1954.

The numbers of liberations and recaptures from these experiments are given in Table 9.

On the basis of these rather limited data it would seem that better returns would result from the adoption of the bridle attachment, possibly as the result of a reduction in the incidence of tag shedding. Larger scale experiments to test the relative merits of these two attachments will be made in 1954, both in the aquarium and in the open sea.

Discussion.

The recaptures obtained from the experiments in the years 1951—53 provide adequate material from which to assess the respective merits and shortcomings of the one-man tagging technique from commercial drift-net vessels, on which almost the whole of the Scottish contribution to the European herring tagging programme has been based.

It is evident from the data which have accumulated since 1951 that this technique has satisfied the initial demands of much greater numbers of liberations and recaptures per unit cost than hitherto, and has at the same time allowed the rather limited resources of one research vessel to be used entirely for other important investigations. These, it is considered, are considerations of very great importance, which can be over-ruled only if the technique is failing to provide some essential data which would be forthcoming from the adoption of an alternative, more expensive technique.

The least satisfactory feature of the results to date is the very low return of fish which have been at liberty for more than a year. This is shown in Table 10 which gives the numbers of recaptures after successive three monthly intervals from all the North Sea experiments made between 1951 and 1953.

Table 10.

Time at liberty	Number of recaptures	%
Up to 3 months ...	376	81·9
3—6 – ...	72	15·7
6—9 – ...	9	2·0
9—12 – ...	—	—
12—15 – ...	2	0·4
15—18 – ...	—	—
Over 18 – ...	—	—

Since the herring fished in the north-western North Sea during the summer months in recent years have consisted mainly of an indigenous stock of autumn spawning herring which are probably fished intensively throughout the greater part of the year, the most likely explanation of the absence of the long-term recaptures must be sought amongst the various sources of tag loss, collectively termed "tagging mortality". The two most likely sources are (1) deaths of tagged fish due either to the direct effect on the fish of the tag itself or its attraction of predators, and (2) the shedding of tags after long periods at liberty. The second of these sources is considered to be the more important and it was in an attempt to reduce this loss that experiments with a further bridle attachment were undertaken in 1953. It will not be possible, however, to assess the relative merits of the two attachments and to determine whether the numbers of long-term recaptures can be increased substantially by the use of the bridle attachment until further field and aquarium trials have been made. The alternative possibility that liberated drift-net caught herring, whether tagged or not, suffer a relatively high mortality after several months at liberty cannot be ruled out.

It is thought that the poor returns from the Minch experiments are associated with the absence of areas of shoal concentration, such as are found on the Fladen Ground and in the region of the Dogger, where the shoals are much more effectively exploited by trawl than by drift-net. Recently, there has been a substantial increase in the proportion of the Minch catch which is bulk-handled in reduction plants; in 1953 the quantity so processed amounted to 68 % of the total catch. Steps are being taken, therefore, to install magnetic tag separators at the main reduction plants in this area with a view to the introduction of internal tagging in the Minch.

At the present time it is not considered possible to change from the basic method of external tagging in the North Sea because of the lack of tag separators in the reduction plants of most European countries. In view, however, of the present trends in the disposal of the European catch from the North Sea it is becoming increasingly clear that, in order to maintain an effective herring tagging programme in the North Sea, steps should be taken to have magnetic separators installed in herring meal and oil plants. When this is accomplished on a large scale a major change in the North Sea tagging technique will be justified. It is considered that future developments in herring tagging in the North Sea should be towards "combination" external tags which can be separated magnetically from reduction plants as well as readily spotted in lots of fish treated for human consumption. The experiments with the Scottish tag containing a metal strip, although unsuccessful in themselves, provided information which pointed to the possibility of developing an effective combination tag. Trials with a new design of such a tag will be made in the Scottish experiments in 1954.

PART II.

Biological Results from Scottish Tagging Experiments.

Introduction.

This part of the paper deals with the more important biological results which have emerged from the Scottish tagging experiments. Preliminary reports of some of these have already been submitted at the Council's meetings in 1951 and 1952 (e. g., Wood, 1951, McPherson, 1952) and further summaries of each year's recaptures are contained in *Annales Biologiques*, Volumes VI to IX.

Area distribution of recaptures. The areas in which recaptures have been made from all experiments since 1948, excluding those on the juvenile stocks in the Moray Firth and Firth of Forth, and that off the Swedish coast (see report by Dr. H. Höglund), are listed in Tables 11—14. These give the numbers of recaptures in each main fishing region from each month's liberations in each tagging locality; only those records for which there is complete information as to time and place of recapture are included. The number of records, which were unusable due to the absence of this information, was small, but for completeness they are recorded under "unusable" records in the tables. Most of the data are reproduced in Charts 1—10.

Before any biological interpretation of these results can be made, it is necessary to consider the more important factors which may influence the numbers of recaptures in different areas and which, if not fully recognized, may lead to faulty biological interpretation. The most important of such possible factors are:—

1. The distribution and amount of fishing effort.

It is an obvious limitation of all such tagging experiments that recaptures can only come from areas in which fishing takes place. Furthermore, the chances of recaptures will be a function of the amount and kind of fishing effort to which the population of tagged fish is subjected after liberation.

2. The influence of the fishing gear on tag loss at recapture.

Recaptures in the different fisheries will not be representative if the incidence of tag loss differs with the type of fishing gear used. This factor may be important in the present enquiry since tag loss on recapture by drift-net is thought to be higher than by trawl.

3. Differences in the chances of the tags being spotted in the catches taken by different gears and in different handling processes on board ship and ashore.

4. Differences in the awareness of fishermen and other operatives in different areas to the tagging experiment.

The composition of the herring fisheries in the North Sea is such that all of these factors are important in the present enquiry. It is evident that a full quantitative appraisal of the recapture data cannot be made without complete details of the distribution of fishing effort by each type of gear in the North Sea and its approaches. Unfortunately this information is not available for any of the years in which liberations have been made, and in consequence it is not possible to assess accurately the magnitude of a migration from one area to another. The problem is further complicated by the suspected relatively high (but unknown) increase in the incidence of tag shedding after periods at liberty exceeding four months.

For these reasons deductions from the recapture data must be to a large extent tentative and qualitative. Nevertheless they provide some important and interesting pointers to the migrations undertaken by the herring populations which inhabit the north-western North Sea in the summer months. The tagging results confirm some of the deductions made from other biological data and indicate new channels of future investigation.

Table 11. Records of Recaptures of Herring tagged in the Years 1948, 1949 and 1950.

Area of liberation and number tagged	Area of recapture	Month of tagging				Total	%
		May	June	July	August		
Shetland-Orkney May = 70 June = 1263 July = 105	Fladen	1	6	Nil	—	7	100·00
Scottish NE. coast May = 2265 June = 960 July = 1482 Aug. = 1040	Scottish NE. coast	1	2	—	3	6	37·50
	Fladen	1	2	2	Nil	5	31·25
	Gut	1	—	—	Nil	1	6·25
	English NE. coast	1	—	—	Nil	1	6·25
	Dogger	1	—	1	Nil	2	12·50
	Skagerak	1	Nil	Nil	Nil	1	6·25
	Total	6	4	3	3	16	100·00

Table 12. **Records of Recaptures of Herring tagged in 1951.**

Area of liberation and number tagged	Area of recapture	Month of Tagging May	June	July	Aug.	Sept.	Total	%
Shetland-Orkney June = 1247 July = 720	Shetland	—	1	Nil	—	—	1	5·6
	Scottish NE. coast	—	1	Nil	—	—	1	5·6
	Fladen	—	8	6	—	—	14	77·6
	Dogger	—	1	Nil	—	—	1	5·6
	Skagerak	—	1	Nil	—	—	1	5·6
	Total	—	12	6	—	—	18	
	Unusable records	—	Nil	Nil	—	—	Nil	
Scottish NE. coast Apr. = 28[1] May = 1458[2] June = 1703 July = 1827 Aug. = 494 Sept. = 150	Scottish NE. coast	13	6	5	1	1	26	27·4
	Fladen	16	20	9	Nil	Nil	45	47·4
	Gut	4	1	2	Nil	Nil	7	7·4
	English NE. coast	4	Nil	Nil	Nil	Nil	4	4·2
	Dogger	7	3	Nil	Nil	Nil	10	10·4
	East Anglia	2	Nil	Nil	Nil	Nil	2	2·1
	Skagerak	1	Nil	Nil	Nil	Nil	1	1·1
	Total	47	30	16	1	1	95	
	Unusable records	4	6	2	Nil	Nil	12	
North Minch June = 299 July = 200 Sept. = 359[1] Oct. = 51[1] Dec. = 24[1]	North Minch	—	2	Nil	—	1	3	75·0
	South Minch	—	Nil	Nil	—	1	1	25·0
	Total	—	2	Nil	—	2	4	
	Unusable records	—	Nil	Nil	—	Nil	Nil	

[1]) Liberations made from F. R. S. "Clupea"
[2]) Includes 18 liberations from F. R. S. "Clupea"
} Liberations and recaptures not included in Table 3.

Review of Scottish Tagging Experiments.

The Scottish tagging experiments were generally undertaken at the beginning of the commercial fisheries or soon afterwards; that is when an important phase in the herring movements was in progress or had just been completed. We have no precise information as to the origin or origins of these shoals but from the subsequent movement of the shoals it is inferred that a large proportion of them must have come from more southerly parts of the North Sea.

By reference to Tables 11—14 and Charts 1—10 the following important features will be noted.

1. The relatively small numbers of recaptures from the areas in which tagged fish were liberated.
2. The high incidence of recaptures from the Fladen Ground.
3. The wide spread of recoveries within the boundaries of the North Sea.
4. The absence of recoveries from areas beyond the limits of the North Sea and its near approaches.

Shetland and the Scottish NE. Coast.

An unexpected result from the tagging experiments off Shetland and the Scottish north-east coast has been the small number of recoveries of tagged fish within the tagging areas. It will be seen, for example, from Tables 15 and 16 that only 4.4 % of the recaptures of herring tagged at Shetland were caught in Shetland waters, while only 19.3 % of the recoveries obtained from the tagging experiments made off the north-east of Scotland were caught within or near the area of liberation.

During the few years in which tagging experiments have been made the drift-net fishery at Shetland has invariably declined after a relatively promising beginning in May and the inference to be drawn from fishing results is that a movement of herring shoals away from the Shetland grounds has taken place in June in some years towards the end of May. The very low recovery of only 4.4 % of the total number of recaptures from the Shetland tagging experiments tends to confirm that in recent years the herring shoals have not persisted for long on the Shetland grounds.

The fishery off the north-east coast of Scotland, on the other hand, has been maintained in recent years at a much higher level than at Shetland, which undoubtedly accounts for the much higher proportion of recaptures of tagged herring within or near the tagging area. The number of recaptures of tagged fish, however, both at Shetland and off the Scottish NE. coast is very small compared with the number recovered by trawlers on the Fladen Ground. There is some reason for suspecting that fishing by drift-net leads to a considerably greater loss of tags than fishing by trawl, although one feels that the loss of tags alone in the drift-net fishery does not account for the relatively small numbers of recaptures of tagged herring on the Scottish drift-net grounds.

The outstanding feature of the tagging experiments at Shetland and off the Scottish NE. coast is the con-

Table 13. **Records of Recapture of Herring tagged in 1952.**

Area of liberation and number tagged	Area of recapture	Month of tagging						Total	%
		Febr.	Apr.	May	June	July	Aug.		
NE. North Sea (Coral Bank) April = 1308	Gut	—	1	—	—	—	—	1	16·7
	Skagerak	—	5	—	—	—	—	5	83·3
	Total	—	6	—	—	—	—	6	
	Unusable records	—	Nil	—	—	—	—	Nil	
Shetland May = 271 June = 1545 July = 864 Aug. = 299	Shetland	—	—	Nil	2	Nil	Nil	2	4·3
	Scottish NE. coast	—	—	1	Nil	Nil	Nil	1	2·1
	Fladen	—	—	4	30	5	2	41	87·2
	Dogger	—	—	Nil	2	Nil	Nil	2	4·3
	Skagerak	—	—	Nil	1	Nil	Nil	1	2·1
	Total	—	—	5	35	5	2	47	
	Unusable records	—	—	Nil	6	1	Nil	7	
Scottish NE. coast April = 121[1]) May = 2764[2]) June = 3087 July = 1930 Aug. = 1218	Shetland	—	—	1	Nil	Nil	Nil	1	0·6
	Scottish NE. coast	—	—	1	11	5	6	23	13·2
	Fladen	—	—	24	58	35	1	118	67·8
	Gut	—	—	1	6	2	Nil	9	5·3
	English NE. coast	—	—	3	4	1	Nil	8	4·6
	Dogger	—	—	6	4	1	Nil	11	6·3
	East Anglia	—	—	Nil	2	1	Nil	3	1·7
	Skagerak	—	1	Nil	Nil	Nil	Nil	1	0·6
	Total	—	1	36	85	45	7	174	
	Unusable records	—	Nil	13	19	2	Nil	34	
		Febr.	Mar.	June	July	Aug.	Nov.		
North Minch Febr. = 889 Mar. = 200 July = 300 Aug. = 1996	North Minch	6	Nil	—	2	6	—	14	77·8
	South Minch	Nil	Nil	—	Nil	4	—	4	22·2
	Total	6	Nil	—	2	10	—	18	
	Unusable records	Nil	Nil	—	Nil	2	—	2	
South Minch June = 156 July = 343 Nov. = 150[1])	North Minch	—	—	Nil	Nil	—	Nil	Nil	—
	South Minch	—	—	1	1	—	1	3	100·0
	Total	—	—	1	1	—	1	3	
	Unusable records	—	—	1	2	—	Nil	3	

[1]) Liberations made from F.R.S. "Clupea".
[2]) 785 Liberations made from F.R.S. "Clupea", giving 4 recaptures.

} Liberations and recaptures not included in Table 4.

vergence of herring from these grounds on to the Fladen, where 84.6 % of the recaptures of the herring tagged at Shetland and 58.5 % of the recaptures of the herring tagged off the Scottish north-east coast were recovered for the most part in July and August.

This result is important for it establishes beyond doubt that an important component of the herring caught by trawlers on the Fladen Ground from mid-July until about the end of August are derived from shoals, which are exploited by British drifters on the Scottish drift-net grounds earlier in the season.

In view of the proximity of the Fladen to the drift-net grounds off the Scottish NE. coast, there would appear to be a possibility of day to day exchanges taking place between the shoals on the drift-net grounds and those on the herring trawling grounds. One notes, however, from Table 15 that, while 84.6 % of the recoveries of herring tagged at Shetland were recaptured on the Fladen Ground, only 2.2 % were caught during the same period on the drift-net grounds off the Scottish NE. coast. This result would appear to imply that, following the concentration on the Fladen which begins about mid-July, there is little or no return movement during the remainder of the fishing season to the drift-net grounds off the NE. coast or off Shetland.

The shoals of the Fladen Ground include a small proportion of spring spawning herring. In recent years the proportion has been very small. The chief constituent from mid-July until the end of August or about mid-September has been herring of an autumn spawning type the majority at maturity stages IV and V. The Fladen is not a spawning ground and there seems to be no reason why herring should remain concentrated in that area. On the other hand, it is perfectly clear from the progress and location of the trawl fishery that besides the convergence of herring shoals on the Fladen Ground shoals of herring move southwards along the Gut in August and September. It would appear, in fact, that the Fladen

Table 14. **Records of Recaptures of Herring tagged in 1953.**

Area of liberation and number tagged	Area of recapture	Month of tagging					Total	%
		Apr.	May	June	July	Aug.		
Shetland May = 338 June = 565 July = 85	Shetland	—	Nil	1	Nil	—	1	5·3
	Fladen	—	6	8	1	—	15	79·0
	Dogger	—	1	Nil	Nil	—	1	5·3
	Skagerak	—	2	Nil	Nil	—	2	10·4
	Total	—	9	9	1	—	19	
	Unusable records	—	Nil	Nil	Nil	—	Nil	
North of Fladen (58°45′N., 01°00′E.) Apr. = 200 May = 400	Scottish NE. coast	Nil	1	—	—	—	1	14·3
	Fladen	Nil	1	—	—	—	1	14·3
	Dogger	4	1	—	—	—	5	71·4
	Total	4	3	—	—	—	7	
	Unusable records	1	1	—	—	—	2	
Scottish NE. coast May = 3995 June = 1418 July = 1229 Aug. = 169	Scottish NE. coast	—	6	2	4	Nil	12	19·4
	Fladen	—	22	2	11	Nil	35	56·5
	Gut	—	2	Nil	1	Nil	3	4·8
	English NE. coast	—	2	1	Nil	1	4	6·4
	Dogger	—	3	1	1	Nil	5	8·1
	East Anglia	—	Nil	Nil	1	Nil	1	1·6
	Skagerak	—	Nil	1	1	Nil	2	3·2
	Total	—	35	7	19	1	62	
	Unusable records	—	6	Nil	Nil	Nil	6	
North Minch July = 889 Aug. = 2269	North Minch	—	—	—	1	4	5	71·4
	South Minch	—	—	—	1	1	2	28·6
	Total	—	—	—	2	5	7	
	Unusable records	—	—	—	Nil	2	2	

Table 15. **Recaptures of Herring tagged at Shetland, 1948—53.**

Area of recapture	Month of tagging				Total	%
	May	June	July	Aug.		
Shetland	—	4	—	—	4	4·4
Scottish NE. coast	1	1	—	—	2	2·2
Fladen	11	52	12	2	77	84·6
Dogger	1	3	—	—	4	4·4
Skagerak	2	2	—	—	4	4·4
	15	62	12	2	91	100·0

Table 16. **Recaptures of Herring tagged off Scottish NE. Coast, 1948—1953.**

Area of recapture	Month of Tagging						Total	%
	Apr.	May	June	July	Aug.	Sept.		
Shetland	—	1	—	—	—	—	1	0·3
Scottish NE. coast	—	21	21	14	10	1	67	19·3
Fladen	—	63	82	57	1	—	203	58·5
Gut	—	8	7	5	—	—	20	5·8
English NE. coast	—	10	5	1	1	—	17	4·9
Dogger	—	17	8	3	—	—	28	8·1
East Anglia	—	2	2	2	—	—	6	1·7
Skagerak	1	2	1	1	—	—	5	1·4
	1	124	126	83	12	1	347	100·0

is a collecting basin from which the shoals pass into the Gut en route for spawning places in the middle and southern North Sea.

Normally few herring at maturity stages IV and V are to be found on the Fladen Ground after the first or second weeks of September, when the population begins to consist more and more of spent fish, which have spawned on banks near the Scottish coast. It would appear, therefore, that the Fladen herring population from about mid-July until about mid-September is not a stationary but a migrating population and that convergence on the Fladen Ground is a first or an early step in the southerly migration to spawning places in the middle and southern North Sea.

It has long been known that an important change takes place about mid-July in the composition of the herring catches from the drift-net grounds at Shetland and off the Scottish NE. coast and after mid-July there is a very rapid increase in the proportions of fish which are due to spawn near the Scottish NE. coast in August and September (Wood, 1937). In this connexion it is interesting to refer the recaptures from between the Gut and East Anglia to their months of tagging which are as follows:—

	May	June	July	August	Total
Recaptures	38	25	11	1	75
%	50·7	33·3	14·7	1·3	100·0

From these figures it will be seen that 84 % of the recaptures from the Gut and grounds further south had been tagged in May and June.

It has already been noted that there is evidence of a heavy loss of tags after three or four months and so there is little doubt that the magnitude of the migration from the north-western North Sea towards the Dogger and adjacent area in late summer and autumn is much greater than is indicated by the number of tagged fish recovered.

It has already been suggested that the movement into the Gut and towards the Dogger and the grounds off NE. England has been made via the Fladen Ground. Confirmation of this movement is still lacking in the Scottish tagging experiments since Scottish tagging experiments with trawl-caught herring on the Fladen in August and September have been singularly unsuccessful; none of the fish tagged so far appear to have survived for more than a week.

Another interesting feature in the experiments has been the recovery in the Skagerak of herring tagged at Shetland and on grounds off the Scottish NE. coast. They are given here according to the months of tagging.

April	May	June	July	Total
1	4	3	1	9

See Charts 1, 2, 5, 6, 8 and 9.

Unfortunately two records have been inadvertently omitted from Charts 3 and 10. The details of liberation and recapture of these records are as follow:—

	Liberation		Recapture	
	Date	Position	Date	Position
1.	28. June 1951	Lat. 59°56′N. Long. 0°50′W.	7. March 1952	Skagerak
2.	17. July 1953	Lat. 58°08′N. Long. 0°45′W.	4. Febr. 1954	Skagerak

Reviewing the Skagerak recaptures as a whole we note that one was recaptured in November and the remainder in January or February. All were in a condition of recovering after spawning.

It will be noted that these recaptures in the Skagerak belonged to that component of the North Sea herring stock which was present on the drift-net grounds at Shetland and off the Scottish NE. coast during the earlier part of the summer and it is presumed that they too moved first to the Fladen Ground and thence southwards along the Gut towards their spawning places.

So far the movements discussed form a fairly clearly defined pattern but records occur which do not conform with the main pattern of movement. An interesting series of recoveries, for example, resulted from tagging experiments in the neighbourhood of the Coral Bank in April 1952 (see Chart 5). One fish was recaptured near the west coast of Denmark in May while 4 others were recovered in the Skagerak between 27. June and 8. July, i. e., within a period of 11 days and a solitary specimen was recaptured in August in the region of the Gut. Examination of samples caught in the neighbourhood of the Coral Bank has shown that both spring and autumn spawning types occur in this region in March and April, and it is very probable that the different movements shown by the herring tagged here in April 1952 were associated with that fact. It is anticipated that such apparently unusual features in the migration routes will become intelligible as tagging experiments are extended.

Another apparently exceptional record is associated with a herring tagged off Fraserburg in May 1952 which was recaptured near the SE. coast of Shetland in June 1953 (see Chart 5). The herring which spawn in autumn near Shetland and along the Scottish NE. coast, belong to the same stock and exchanges take place between the Shetland and the north-east grounds. Furthermore, there is a tendency for herring of the Scottish autumn spawning type to extend their range northwards with increase in age so that the record should not be regarded as exceptional. In fact, it is thought that more such records are to be expected, when the Shetland herring fishery returns to its normal productivity.

The tagging results show a very wide dispersal within the North Sea of herring which were present at Shetland and off the Scottish NE. coast in May and June. It is to be noted, moreover, that up to the end of 1953 no herring tagged by the Scottish method in the north-western North Sea has so far been recovered either from the west coast of Scotland or

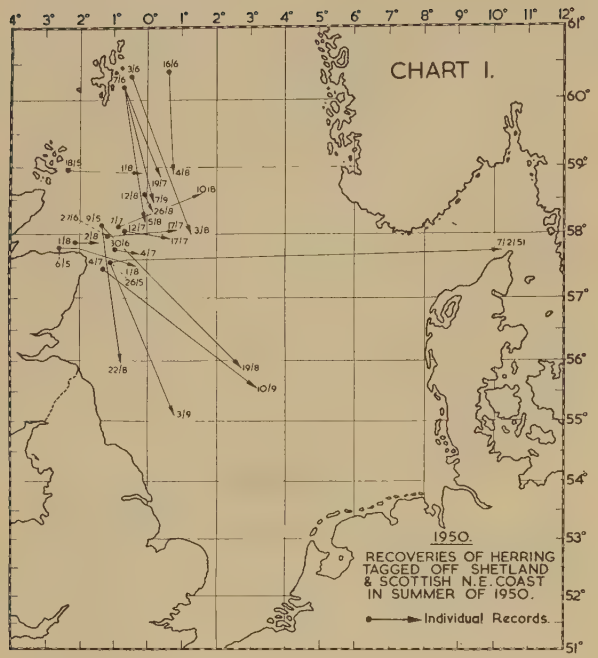


CHART 1.
1950.
RECOVERIES OF HERRING TAGGED OFF SHETLAND & SCOTTISH N.E. COAST IN SUMMER OF 1950.
Individual Records.

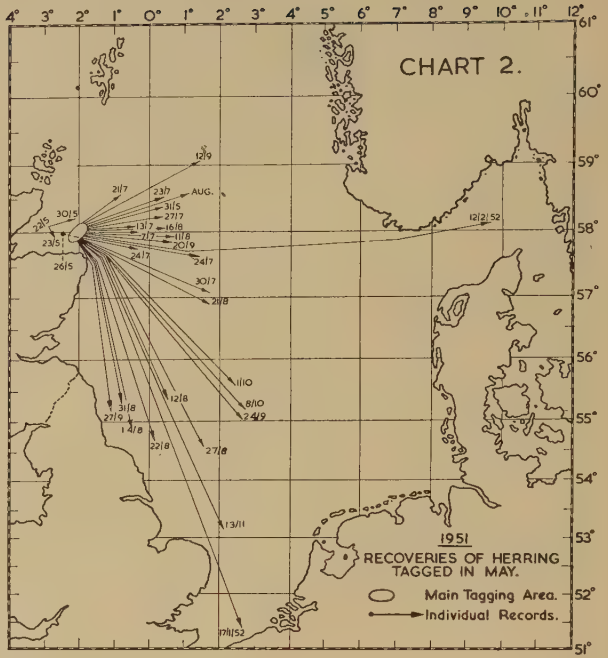


CHART 2.
1951
RECOVERIES OF HERRING TAGGED IN MAY.
Main Tagging Area.
Individual Records.

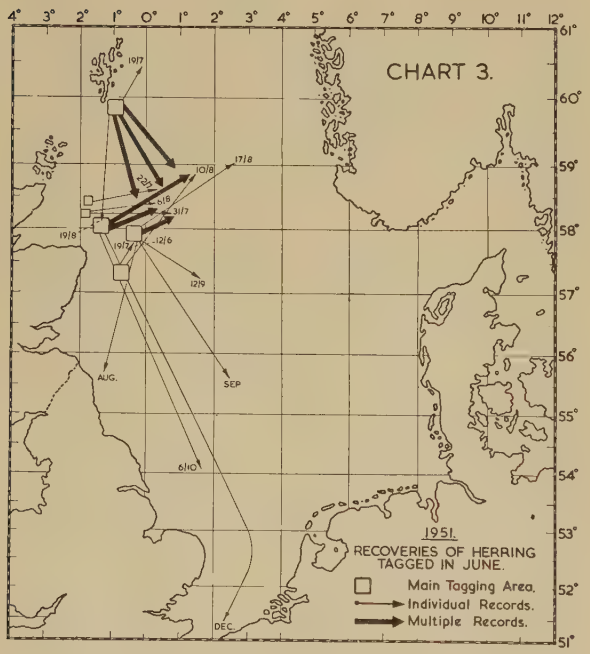


CHART 3.
1951.
RECOVERIES OF HERRING TAGGED IN JUNE.
Main Tagging Area.
Individual Records.
Multiple Records.

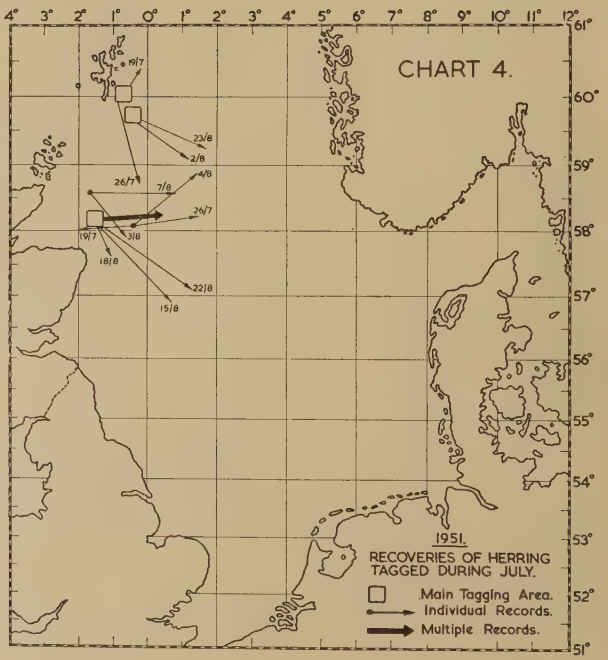


CHART 4.
1951.
RECOVERIES OF HERRING TAGGED DURING JULY.
Main Tagging Area.
Individual Records.
Multiple Records.

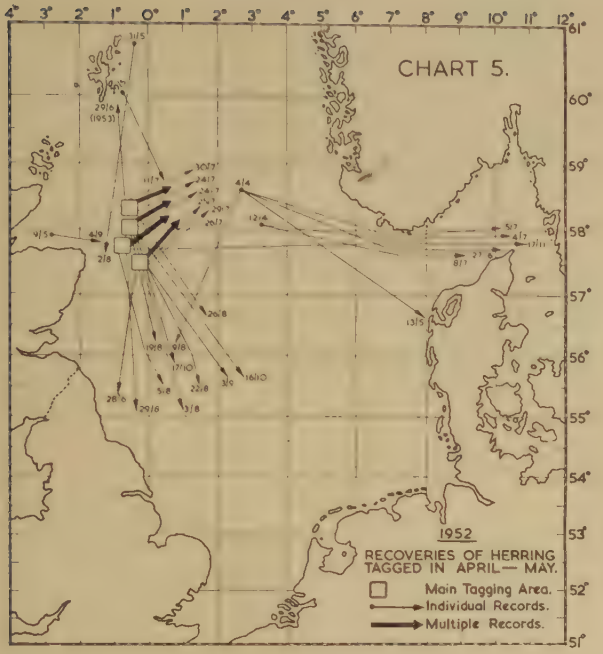


CHART 5.
1952
RECOVERIES OF HERRING TAGGED IN APRIL— MAY.
Main Tagging Area.
Individual Records.
Multiple Records.

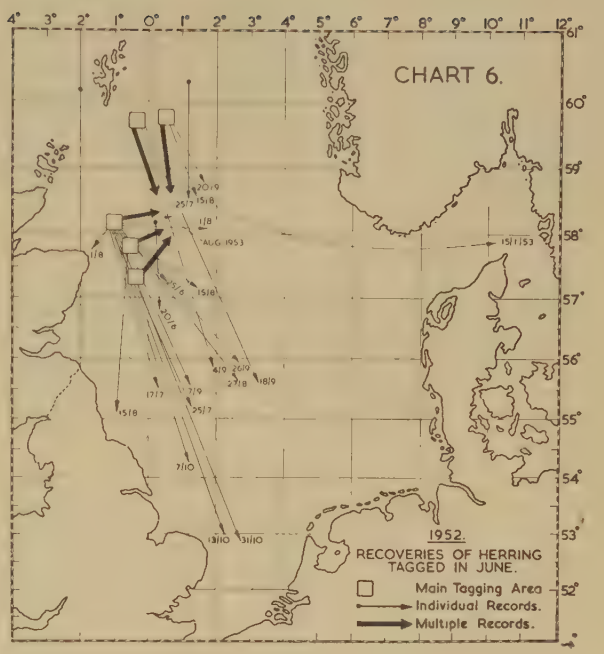


CHART 6.
1952.
RECOVERIES OF HERRING TAGGED IN JUNE.
Main Tagging Area
Individual Records.
Multiple Records.

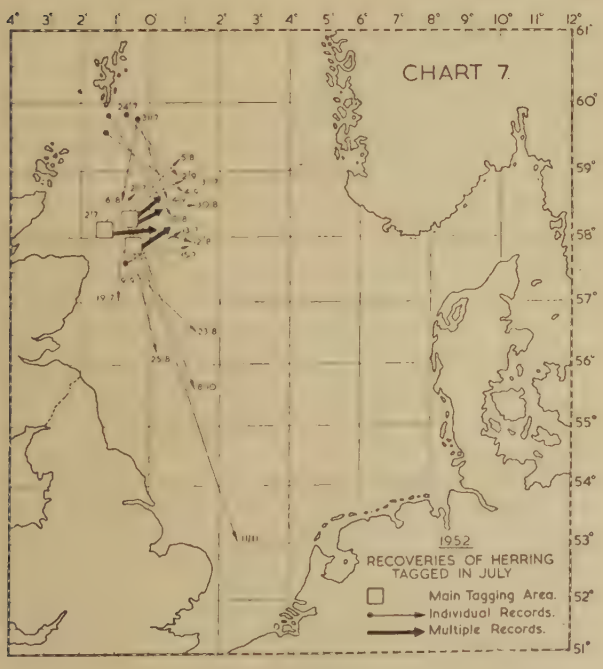


CHART 7.
1952
RECOVERIES OF HERRING TAGGED IN JULY
Main Tagging Area.
Individual Records.
Multiple Records.

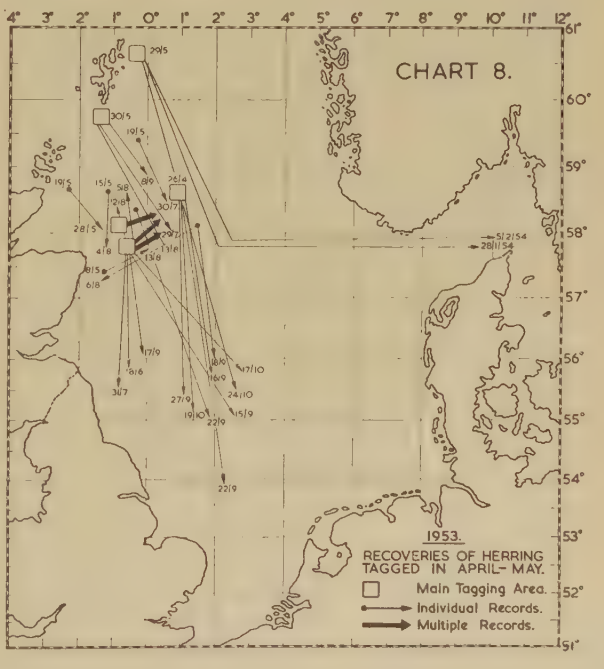
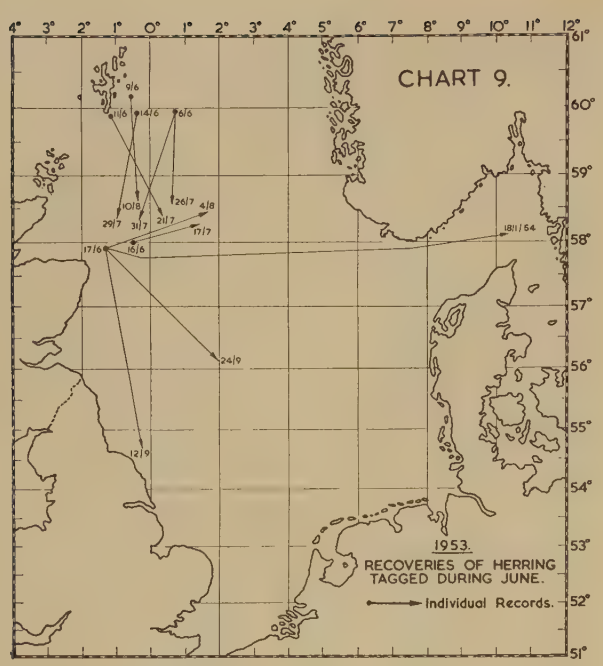
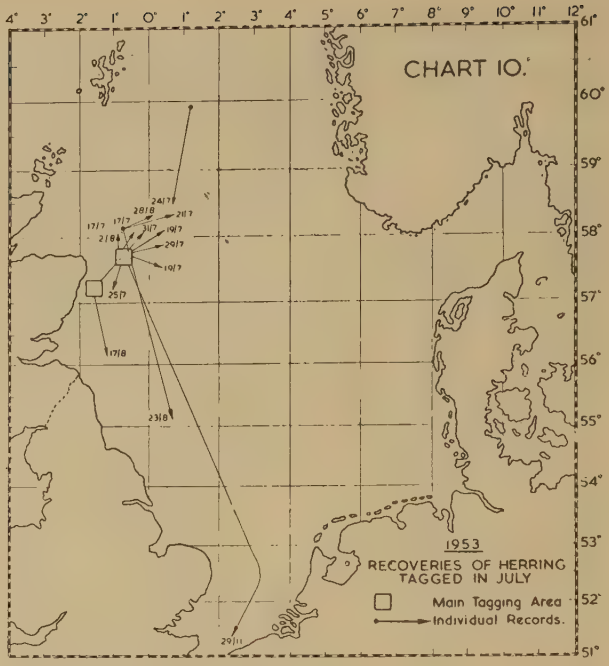


CHART 8.
1953.
RECOVERIES OF HERRING TAGGED IN APRIL- MAY.
Main Tagging Area.
Individual Records.
Multiple Records.





from the fisheries on the west coast of Norway. We shall see later that likewise there has been in the same period no recorded movement from the west and north-west of Scotland into the North Sea. The herring fisheries of the east and west coasts of Scotland appear to fluctuate independently of each other and while some exchange may take place there has been no evidence to indicate exchanges on a large scale.

The absence of records of recapture of Scottish tagged herring near the Norwegian west coast is less surprising since the bulk of the Norwegian catch is converted into meal and oil and the Scottish or any other non-magnetic tag has little chance of being observed in the process.[1])

A few herring tagged near the west coast of Norway with internal magnetic tags have been recovered at a meal and oil plant in Shetland, and herring having the distinctive characteristics of Norwegian herring have been observed not infrequently in the catches from the north-western North Sea in May and June. In recent years, however, spring spawning herring have been much less conspicuous than usual in the catches of the north-western North Sea. Accordingly, when spring spawners recover to something approaching their normal abundance on the Shetland and adjacent grounds there should be a reasonable chance of some recoveries of Scottish tagged herring in the Norwegian fisheries.

West Coast Experiments.

The recaptures of herring tagged on the Minch grounds have been disappointingly few, and at this stage one can only speculate as to the reason for this. During recent years the shoals exploited within the Minch have consisted very predominantly of autumn spawning herring. The fishery is carried on by drift- and ring-nets; there is no trawling. The possibility has already been suggested that drift-nets cause a heavier loss of external tags than the trawl and this may be part of the explanation for the poor recovery of tags on the west coast. At the same time a considerable proportion of the catch is taken by ring-net which, one would imagine, should be no more destructive of tags than the trawl. On the other hand, it should be kept in mind that the ring-net is used only at night and the catch is emptied directly into the fish hold, so that in fact the chances of a tagged fish being spotted in a ring-net catch are considerably less than in a trawl catch. Furthermore, a very large proportion of the west coast catch, more especially in autumn and winter, is consigned to meal and oil plants so that the prospects of recovering tagged herring on the west coast of Scotland are appreciably less than on the east coast.

No pattern of movement can be discerned from the few recoveries recorded from the west coast. One herring liberated off South Uist in July 1952 was recaptured in the same area in August 1953. Some

[1]) This survey does not include the recaptures made in 1954 except for the few recorded in the Skagerak in January and February but mention must be made of two new records which may have important biological implications. One herring tagged in the Minch off the Butt of Lewis on 7. August 1953 was recovered on the Fladen Ground on 9. August 1954. Another tagged 53 miles E. x S. of Peterhead on 4. June 1952 was recaptured near the west coast of Norway in the region of latitude 62°33′N. on 3. October 1954.

herring tagged on the north part of the Minch have been recaptured in the southern part, and one fish tagged off the east coast of Lewis in Febuary 1952 was recaptured on the east side of the Minch in February 1954. This is the only Scottish record of a two years interval between liberation and recapture.

A tentative conclusion is that the autumn spawning herring fished throughout the Minch constitute a common stock which circulates within its boundaries.

Tagging of "Halflin" Herring.

In 1952 and 1953 tagging experiments were conducted on the adolescent "halflin" herring stocks which inhabit the upper reaches of the Firth of Forth and the Moray Firth. Fisheries for these herring, which are mostly in their third year of life, are conducted by small-meshed drift- and ring-net in the winter months between November and March, after which the fish migrate from the areas. The objective of these tagging experiments was to trace the movement of these emigrants, after they left the nursery areas.

While a number of tagged fish was recaptured within the estuaries during the tagging season, none has been recaptured so far in the open sea.[1]) More extensive experiments have been planned for the winter of 1954.

[1]) Since this report was prepared one recovery has been reported from the drift-net grounds off the Scottish north-east coast. The tagged fish was liberated in the upper reaches of the Moray Firth in March 1954, and was recaptured 35 miles east from Peterhead on 21.7.1954.

Summary.

Part I of this paper deals with the methods used since 1948 in the Scottish tagging experiments, and discusses the relative merits of the different tag types and tagging techniques which have been used. Part II summarizes the biological data which have resulted from these experiments.

Summary of Part I.

In the years 1948—1950, tagging experiments were conducted in the North Sea from catches made by drift-net aboard F.R.S. "Clupea". A number of external tag types were used, which included a plastic band tag, a plastic "flag" tag, a coloured rubber band and Lea's hydrostatic tag. About 7,000 liberations were made in different parts of the northern North Sea in the three years and twenty-three recaptures were recorded. These showed that selected herring could survive capture by drift-net and subsequent tagging.

This method of tagging was costly and time consuming, and in 1951 trials were first made with a "one-man" tag on board commercial drifters. A much larger number of herring were tagged much more cheaply by this method, and a larger number of recaptures were reported than in the previous three years. This method has been adopted in all subsequent experiments.

Aquarium observations of herring tagged with the one-man tag show that tag shedding may be substantial after periods at liberty greater than four months. This might be a main contributory cause of a marked fall-off in the numbers of recaptures after periods exceeding four months at liberty.

Comparisons between tag types and colours showed that the Scottish tag possessing a bright yellow component and the Lea tag were about equally effective when used with the one-man technique. Scottish tags without a bright yellow component proved less effective than the Lea tag. Conspicuousness on recapture is thought to be the major reason for the greater effectiveness of the bright yellow tag.

Comparative experiments between the meticulous Swedish tagging technique, in which Lea tags were used, and the one-man Scottish technique show a higher percentage recapture from the Swedish methods, particularly after intervals exceeding three months. It is thought that the main reason for this difference was the higher incidence of tag shedding of the Scottish tags. To reduce this, trials have been made with a new form of one-man bridle attachment which will be used in the Scottish experiments in 1954.

The limitations of external tagging in the North Sea and Scottish west coast experiments are discussed and because of a progressive increase in bulk-handling of the catch the need for a combination external tag which is both magnetic and conspicuous is stressed. It is further recommended that steps be taken to effect the installation of magnetic separators in all European reduction factories.

Summary of Part II.

The main objectives of the Scottish tagging experiments have been to trace the movements of herring from the summer concentrations of autumn spawners in the north-western North Sea and from the summer and winter concentrations in the North and South Minch. Experiments have also been made on the adolescent "halflin" stocks of the Moray Firth and Firth of Forth to trace their offshore movements.

No herring tagged inside the North Sea has been recaptured outside its immediate approaches, but recoveries have come from widely separated localities within its boundaries.

The greatest numbers of recaptures from liberations in the north-western North Sea have been made on the Fladen Ground, and others have come from central and southern North Sea fisheries including those on the Gut, the Dogger Bank, off the English north-east

coast, at East Anglia and in the eastern Channel. It is evident that a substantial part of the autumn spawning stock which frequents the northern North Sea in summer subsequently moves to the south in late summer and autumn, probably via the Fladen Ground and the Gut, and that probably a reverse migration takes place in the eastern North Sea in winter and spring when some of the fish penetrate the northern Skagerak.

The small number of recaptures from liberations made in the Minch show no migrations outside its boundaries, but point to a free circulation of herring within its limits. The only Scottish record of a two-year interval between liberations and recapture was reported in February 1954 from the North Minch, about 50 miles from the point of liberation.

All recaptures of taggings of "halflin" herring have been taken on the nursery grounds. Larger scale experiments on these stocks are planned.

Acknowledgements.

The Scottish tagging programme has been carried out by a team of workers, all of whom have contributed to the delvelopment of the tags and tagging methods used and have taken part in the experiments at sea. Acknowledgement is made of the important part played by Mr. G. Davies in the development of the "toggle" attachment and in the first experiments on commercial drifters in 1951, to our colleagues, Messrs. Baxter, Bruce, Grierson, Robinson and Sinclair, who have undertaken much of the work at sea, and to Mr. J. H. S. Blaxter who has supervised the aquarium experiments.

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